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# WORSTED DRAWING AND SPINNING CALCULATIONS

*A PRACTICAL GUIDE  
FOR STUDENTS, APPRENTICES, FOREMEN, AND  
OTHERS OF THE WORSTED TEXTILE TRADE.*

BY

GEORGE H. DAVIES,  
WORSTED SPINNER'S FOREMAN AND MATHEMATICIAN.

With Tables and many worked Examples.



LONDON:  
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## P R E F A C E.

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To assist practical workers in Worsted Drawing and Spinning to attain greater perfection in their art, and to guide them from rule-of-thumb practice to exact principles, the author has gathered together for this little book many notes which have accumulated during twenty years experience. He aims to present under three main heads useful information as to machinery, wool, and machinery and wool in combination, with the derivation of formulæ therefrom. It is hoped the book may prove a practical guide in Worsted Drawing and Spinning Calculations expressed in modern notation. The relative importance of the matter is indicated typographically, and throughout the text will be found worked out examples of a practical kind to assist the reader. Many useful Tables are introduced and reference to these made easy by glancing at the Index where they are classified.

Great care has been taken to avoid errors, but should any have crept in, the author will be grateful to have his attention drawn to them.

G. H. D.

HALIFAX, ENGLAND,  
*February, 1923.*



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# WORSTED DRAWING AND SPINNING CALCULATIONS.

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## CHAPTER I.

### INTRODUCTION.

1. THIS volume has been prepared with the desire to meet the need for a book on the subject of Worsted Drawing and Spinning Calculations.

The writer, having had over 20 years' practical experience, has realised fully how essential it is to use Algebra. One is apt to think that one can proceed without the aid of Algebra—possibly so—but the reader must agree that better progress will be made by its aid.

The tables and formulæ in this volume will be found most useful to the practical man ; the former are entirely new and original, and of the latter, although **some** of them are given as rules in literature on the subject, their derivations are new and are, at least, an expression of practical experience.

The author has in mind a large body of workers who are practical in the true sense of the term—they **know** what should be ; they use rules, the truth of which is proved by results obtained in the daily work. At times they ask themselves the question, "How is this rule arrived at?" "How is it derived?" At other times

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new problems arise, when much time and thought are expended. Sometimes a solution is found, but more frequently the problem remains unsolved. Due to this practical working knowledge of the trade, it is hoped that the reader will find a new inroad to a subject with most elegant and approved methods of investigation which will carry him onwards to further research in a field where much waits to be done in order to become abreast with others.

Let the reader think for a few moments of number. Let that number increase, and increase, and still increase. Try as one may, one cannot grasp or conceive it, and it has well been said, "The numerosity of number." Has it ever occurred to the reader that **one single letter** in the alphabet can take hold, as it were, of that number which the mind—and probably the pen—has been trying to conceive and write. Such is the case, one letter "a" or "b" or "n" representing what one failed to express in mind or arithmetic.

2. The reader, it is assumed, is in charge of a spinning room, and is spinning 60's counts, with a draft wheel, of which 50 teeth is required to spin 50's out of the same rovings. It is necessary to make a calculation to find the draft wheel in order to produce 50's counts. If 60's counts require a wheel of 50 teeth, how many teeth are required in a draft wheel to spin 50's?

Then if 60's = 50 wheel.

„ 1's =  $50 \times 60$ ,

∴ 50's =  $\frac{50 \times 60}{50}$ ,

∴ 50's = 60. *Ans.*

Now, this is all right, as far as it goes, and for any count and every different wheel within the limits of usage of the trade this same reasoning has to be gone through, which, although very simple to the practical man, is not so easy to the apprentice, beginner, or student, more especially when a multitude of other duties are crowded in upon him. Consequently mistakes have been made, and persons in charge of the apprentice have lost their positions.

### 3. Reasoning the same in algebra.

If X counts = A teeth in draft wheel.

Then 1's ,, =  $A \times X$ ,

$\therefore$  Y's ,, =  $\frac{A \times X}{Y}$  = number of teeth in new draft wheel.

In the example  $X = 60$ 's,  $Y = 50$ 's, and  $A = 50$  teeth in draft wheel, and by substituting in

$$Y = \frac{A \times X}{Y}.$$

Then  $Y = \frac{50 \times 60}{50},$

$\therefore$   $Y = 60$  teeth in wheel.

Now  $X =$  present counts spinning,

and  $Y =$  new counts to spin,

and  $A =$  present draft wheel.

4. Hence the rule to find change wheel for draft is by multiplying present counts by its draft wheel and dividing by new counts.

$$\left. \begin{array}{l} \text{New draft wheel or} \\ \text{change wheel} \end{array} \right\} = \frac{\text{present counts} \times \text{its draft wheel}}{\text{new counts}}.$$

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5. Algebra may be considered a " shorthand " method of writing rules, for

Let  $C_p$  = present counts spinning.

„  $A_p$  = present wheel running.

„  $C_n$  = new counts to spin.

„  $A_n$  = new wheel for draft for new count to spin.

Then 
$$A_n = \frac{C_p \times A_p}{C_n},$$

and  $\therefore A_n \times C_n = C_p \times A_p.$

Any **three** of the above factors given and known, the fourth and unknown may be found. The reasoning is done **once** for all arithmetical values, the mind is relieved, and may be used on other work.

6. In order to show, and at the same time impress, the utility of algebra, the problem which follows as a consequence to changing the counts is the lifter change wheel. For 60's counts with a twist wheel of 20 and a lifter wheel of 20 teeth, the 50's counts having a twist wheel of 22 teeth, what wheel is required for lifter change wheel? Reasoning in figures :—

Now 60's counts = 20 teeth in lifter wheel.

Then 1's „ =  $60 \times 20$ .

$$\therefore 50's \quad „ \quad = \frac{60 \times 20}{50} = 24 \text{ teeth.}$$

Now a twist wheel of 20 teeth = 24 lifter wheel.

Then 1 tooth =  $\frac{24}{20}.$

$$\therefore 22 \text{ teeth} = \frac{24 \times 22}{20} = 26.4.$$

$$\therefore 22 \text{ ,, } = 26 \text{ lifter change wheel.}$$

The first part is inverse proportion.

The latter part is direct proportion.

7. Reasoning in algebra, let  $L_p$  = present lifter change wheel.

Then  $C_p$  counts =  $L_p$ ,

and  $1 \text{ ,, } = C_p \times L_p$ .

$$\therefore C_n \text{ ,, } = \frac{C_p \times L_p}{C_n}.$$

Let  $t_p$  = present twist wheel for  $C_p$  counts.

„  $t_n$  = new twist wheel for  $C_n$  counts with  $t_p$  twist wheel.

„  $L_n$  = new lifter wheel for  $C_n$  counts with  $t_n$  twist wheel.

$$\text{Then } t_p = \frac{C_p \times L_p}{C_n}.$$

$$\text{,, } 1 = \frac{C_p \times L_p}{C_n \times t_p}.$$

$$\therefore t_n = \frac{C_p \times t_n \times L_p}{C_n \times t_p} = L_n.$$

8. The rule given for finding lifter change wheel on a spinning frame with a "scaife" motion is present counts multiplied by new twist wheel, multiplied by present lifter wheel, divided by new counts multiplied by present twist wheel.

9. In the example given  $t_p$  = 20 teeth,  $t_n$  = 22 teeth, and  $L_p$  = 20 teeth. Substituting in formula just derived :—

$$\text{Let } L_n = \frac{C_p \times t_n \times L_p}{C_n \times t_p}.$$

$$\text{Then} \quad L_n = \frac{60 \times 22 \times 20}{50 \times 20},$$

$$\therefore \quad L_n = 26 \text{ teeth. } Ans.$$

10. The author has used the notation of algebra to the fullest extent; for instance, if  $a = 2$ , and  $b = 3$ , then  $ab = 2 \times 3 = 6$ . To multiply in algebra, mathematicians have chosen their symbolism to be concise by defining  $xy$  to stand for  $x$  times  $y$ . The **solidus** is frequently used between the numerator and denominator of a fraction in order to save space—e.g.,  $a/b$ . The **vinculum** has been taken advantage of as in the following cases:—

$$k = \frac{a}{b} \times \frac{c}{d} \times \frac{e}{f} = \frac{a}{b} \frac{c}{d} \frac{e}{f} = \frac{ace}{bdf}.$$

$$k = \frac{1}{2} \times \frac{3}{4} \times \frac{5}{6} = \frac{1}{2} \frac{3}{4} \frac{5}{6} = \frac{1 \times 3 \times 5}{2 \times 4 \times 6} = \frac{15}{48}.$$

11. All calculations of numerical examples and tables given have been performed by the shortest methods in arithmetic. The three methods of the watch calculator, slide rule, and logarithms have each been used in several problems. Full advantage has been taken of indices whose properties are those of logarithms. The error of a needless number of decimal places is often prevented by expressing  $5.6 \times 10^7$  and  $5.25 \times 10^7$  instead of 56,000,000 or 52,500,000. This is also convenient in additional ways.

12. In the following table, note should be taken of how many places the decimal point must be moved to convert 5.638 into the number in question.

563,800,000,000	= 5.638 × 10 <sup>11</sup>
563,800	= 5.638 × 10 <sup>5</sup>
56.38	= 5.638 × 10 <sup>1</sup>
5.638	= 5.638 × 10 <sup>0</sup>
0.5638	= 5.638 × 10 <sup>-1</sup>
0.005638	= 5.638 × 10 <sup>-3</sup>
0.00005638	= 5.538 × 10 <sup>-5</sup>

13. The practical man knows generally how many digits he should have in an answer. However, the above helps considerably. The indices 11, 5, 1, 0, - 1, - 3, and - 5 are the characteristics of logarithms.

14. In the body of the book the reader will find in Chapter VIII., Section 107, a whole set of drawing slivers in drams of 80 yards expressed in the Metric and English worsted counts multiplied by 10<sup>3</sup>. The top sliver, 450 drams per 80 yards, equals 0.09175 Metric count, which equals 0.08127 English count; multiplying each by 1,000 or 10<sup>3</sup>, 91.75 metres per kilogramme is obtained, which is permissible, and the special advantage of the metric system of weights and measures is the fact of it being a decimal system like the Arabic notation of numbers and *not* the actual length or actual mass. On the contrary, the English count 0.08127 multiplied by 10<sup>3</sup> gives 81.27 thousandth hank per pound. Consequently, a **millihank** (which is new to the Trade) is created and evolved primarily from expressing number in the afore-shown manner.

15. Note should be taken of the following manner of expressing in writing the under-stated formula—*e.g.*,

$$\text{Now} \quad D = \frac{W \, l^3}{48 \, E \, l}$$



$$\therefore D = W l^3 / 48 E l,$$

$$\text{and} \quad D = W l^3 48^{-1} E^{-1} L^{-1}.$$

16. Neither diagrams nor drawings are given, the reader being asked to make these for himself from the machines.

There is no "royal road" to learning mathematics, and the sooner one becomes well grounded in its principles, the more marked will his progress be in any branch of learning.

17. The symbols used in this work are consistent throughout, and have the advantage of conveying that a change wheel on one machine may have the *opposite* effect on another—*e.g.*, A represents the change draft wheel on a spinning frame, but not so on a cone roving box, this being keyed to the front roller shaft.

The draft race and twist formulæ each contain "*g*" (a change wheel), and consequently when "*g*" is altered in a spindle gill box, it also alters the value of "*T*" turns per inch, hence this must be counteracted. In the draft formula the factors are capital letters, while in the twist formula small letters are used, and when the ratio *g/h* occurs in the draft formula, it immediately suggests that these belong and enter into twist train of wheels.

18. The lifter train of wheels follows in alphabetical order, so that no one letter represents two wheels or pulleys, and where there are two or more such wheels or pulleys, the letter is used with a subscript—*e.g.*, *d* stands for draft, but *d*<sub>1</sub>, *d*<sub>2</sub>, *d*<sub>3</sub> . . . represents a series of drafts in the boxes of a set of drawing.

As the English alphabet becomes exhausted the

Greek is used, but only for carrier race ratios, which investigation, however, is rare.

19. By holding a piece of sliver or roving of a certain length between finger and thumb of each hand and pulling outwards, the sliver is made smaller in diameter and greater in length. In the language of the spinner, the sliver has been "drafted"—the finger and thumb of each hand representing the nips of front and back rollers. In the Trade, these are made to revolve, thus giving a "**rate of drafting**," as well as an amount. If in spinning 60's and 30's counts, a draft of 6 is required, it is evident the rate of drafting is different. In Chapter VIII.,  $d$  (the draft) is the theoretical value calculated as the amount of reduction to be made in each machine or drawing. By placing the sliver in a certain order consistent with practice between the nips of front and back rollers, whose velocity ratio are equal to  $d$ , the draft required is produced.

20. It is this fact that accounts for the three main divisions of the book—*i.e.*, machines, wool, and machines and wool. In the first portion the velocity ratio of draft race is calculated, in the second portion the amount of draft is calculated, and in the third and last portion the sliver is placed in the machines, thus making "velocity ratio" the *cause* equal to draft—*effect*.

21. In questions relating to trains of wheels, there is an advantage in denoting the radii, diameters, or number of teeth on the various wheels by single letters, such as A, B, C, . . . which letters also may indicate the wheels themselves. To the person who has not studied, or at least made himself acquainted with applied mechanics, much confusion exists as to drivers and

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driven in a train of wheels, and to classify them as is requested in literature on the trade seems almost hopeless, and if accomplished is with a measure of uncertainty due to its ambiguity. In any train of wheels, that wheel which causes motion is termed the **driver**, and that which receives the motion is called the **follower**. These terms are applied to *any contiguous* pair of wheels in the train. The combination of two or more gear wheels or pulleys is spoken of as a **train**. Now “*e*” (velocity ratio) represents the value of a train of wheels of pulleys in mechanics, but in this work for obvious reasons it has been called “*d*”—*e.g.*, Chapter II. on Drafts. This has simplified matters greatly, and done away with unnecessary reasoning and chances of error.

The value of any train of wheels or pulleys is represented by

$$e = \frac{A}{B} \frac{C}{D} \frac{E}{F} \cdot \cdot \cdot \frac{Y}{Z}.$$

## CHAPTER II.

## MACHINES—DRAFT RACE.

22. **The draft race gearing** is designed for the purpose of the reduction in the thickness of the sliver. This reduction is accomplished by passing the sliver through two pairs of rollers working in conjunction with each other, but having different surface velocities. Bearing in mind what has already been said on velocity ratio in the Introduction, one is now in a position to apply it for the derivation of formulæ for the various machines in Drawing and Spinning.

The author very well remembers during the first few years of his apprenticeship, and before he acquired a slight knowledge of algebra, how very difficult was the classification of the so-called "*Drivers and Driven*," "*The increasing and decreasing of speeds*," "*The position and function of the various wheels*," and the "*more or less*" rules, methods, and systems in vogue for the classification. The difficulty was increased owing to the fact that one had to make changes quickly and *surely* with a multitude of other duties to which to attend. When one had reasoned out his calculation and performed it, he was no nearer a *sure* rule which would save him this procedure in the future. It was due to this fact that the author was led to study that so valuable a science of algebra—"Universal Arithmetic."

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With the exception of the twisting frame, drafting is carried out in all the operations on the machines, and for this reason a formula will be obtained for these machines which will be complete *once* and for all.

23. The reduction takes place between the nips of the front and back rollers—the distance between these being called the “ratch,” which is governed by the length of staple, quality of wool, and the amount of twist in the sliver in the process of drafting.

For the argument here developed, **draft** may be defined as the “*Ratio of Velocity of Front and Back Rollers.*”

Draft = Ratio of Velocity of Front Roller to Back  
Roller.

24. **The spinning frame** (cap, flyer, and ring), roving, reducing, finishing, and drawing boxes (cone and open) each consists of gearing for draft race of two or four wheels, excluding what are called “idle” wheels.

By letting  $d$  = draft and  $V$  = velocity of front roller “ $R$ ” in inches per min. and  $v$  = velocity of back roller “ $r$ ” in inches per min.

Then is obtained  $d = V/v$ . . . . . (1)

Let  $A$  = number of teeth in wheel on end of front roller shaft called draft wheel, and generally a “change wheel,” but not always.

„  $B$  = number of teeth in wheel follower to  $A$  and called “plate” or *large stud wheel*, seldom used as a change wheel, but in some machines can be so used.

„  $C$  = number of teeth in wheel driver to  $E$ , called

*small* stud wheel, and used occasionally as a change wheel.

Let  $E$  = number of teeth in wheel on end of back roller shaft, called back roller wheel, frequently used as a change wheel.

„  $R$  = diameter of front roller (in inches invariably).

„  $r$  = diameter of back roller (in inches invariably).

„  $n_R$  = number of revolutions of front roller, “ $R$ ” per minute.

$A$  and  $R$  revolve together, and  $E$  and  $r$  revolve together.

$$\text{Now} \quad V = n_R \pi R \text{ and } v = n_R \frac{A}{B} \frac{C}{E} \pi r,$$

and from Equation (1) by substitution.

$$\text{Then} \quad d = n_R \pi R / n_R \frac{A}{B} \frac{C}{E} \pi r.$$

$$\text{„} \quad d = \frac{n \pi R}{1} \times \frac{B E}{n A C} \times \frac{1}{\pi r}.$$

$$\therefore \quad d = \frac{R B E}{r A C} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

(Engineers speak of a “belt race,” and for the same reason the term “draft race” is used in this work.)

25. **The draft race gearing** on spindle gill and can gill boxes consists of two trains of wheels instead of one as in the spinning frame, roving, reducing, finishing, and drawing boxes already mentioned. The first train of wheels is similar to those in spinning frames and drawing boxes; the back rollers are driven by four wheels in gear, excluding “idle” wheels. These are

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represented by A, B, C, and E. What is known as the back shaft of a gill box may be looked upon in this instance to occupy the position of front roller shaft in a spinning frame. I have been told on many occasions in the trade that this suggestion simplifies reasoning of draft race gearing on gill boxes. The second train of wheels is on the other side of the box, and consists of two wheels, excluding "idle" wheels. These wheels are called "*g*" and "*h*" respectively. This train of wheels drives the front roller from the back shaft, which shaft occupies a similar position to the cylinder in a spinning frame, or main shaft in a drawing box. On account of the fact that a large body of men follow spinning only and another drawing only, I have treated the gill box draft race gearing separately, consequently a certain amount of repetition is unavoidable.

26. Letting *d*, *V*, and *v* have same meaning as previously (from Equation 1).

### FIRST TRAIN OF WHEELS.

Let A = number of teeth in wheel on end of back shaft, change wheel.

„ B = number of teeth in wheel follower to A, large stud wheel.

„ C = number of teeth in wheel driver to E, small stud wheel.

„ E = number of teeth in wheel on end of back roller shaft, called back roller wheel.

Wheels A and C are change wheels, but only used for great changes and for adjusting the tension of a back draft.

## SECOND TRAIN OF WHEELS.

Let  $g$  = number of teeth in wheel on the other end of back shaft. (This is chief change wheel, and consequently called draft wheel).

„  $h$  = number of teeth in wheel on front roller shaft, follower to  $g$ . (Keyed on to shaft.)

„  $R$  = diameter of front roller (in inches invariably).

„  $r$  = diameter of back roller (in inches invariably).

„  $n$  = number of revolutions of *back shaft* per minute.

$$„ \quad V = \frac{n g \pi R}{h} \text{ and } v = \frac{n A C}{B E} \frac{\pi r}{1}.$$

Substituting in Equation (1),

$$\text{Then} \quad d = \frac{n g \pi R}{h} \div \frac{n A C \pi r}{B E}.$$

$$\therefore \quad d = \frac{n g \pi R}{h} \times \frac{B E}{n A C \pi r}.$$

$$\therefore \quad d = \frac{R B E}{r A C} \frac{g}{h} \dots \dots \dots (3)$$

Formula 2 is for the spinning overlooker and Formula 3 for the drawing overlooker. These formulæ should be memorised. Formula 3 is for the total draft of a gill box, which comprises a back and front draft.

### 27. To find Front and Back Drafts.

Let  $i$  = number of teeth in driving bevel wheels on back shaft.

„  $j$  = number of teeth in driven bevel wheels on top screw shaft.



## 16 WORSTED DRAWING AND SPINNING CALCULATIONS.

Let  $k$  = pitch of top screws in inches.

„  $v_2$  = velocity of fallers in inches per minute.

„  $d_f$  = front draft = ratio of velocity of front roller to fallers.

„  $d_b$  = back draft = ratio of velocity of fallers to back roller.

Then  $d_f = V/v_2$  and  $d_b = v_2/v$ . . . . . (1<sub>bf</sub>)

Now  $v_2 = \frac{n i k}{j}$ .

(Note.—If  $k$  is single screw, then  $k = 1$   $k = k$ .

If  $k$  is double screw, then  $k = 2$   $k$ .)

But  $d_f = V/v_2$ , and by substituting,

$$\text{Then } d_f = \frac{n g \pi R}{h} \cdot \frac{n i k}{j}.$$

$$\text{„ } d_f = \frac{n g \pi R}{h} \times \frac{j}{n i k}.$$

$$\therefore d_f = \frac{j}{i} \cdot \frac{\pi R}{k} \cdot \frac{g}{h} \quad . \quad . \quad . \quad . \quad . \quad (3_f)$$

But  $d_b = v_2/v$ , and by substituting,

$$\text{Then } d_b = \frac{n i k}{j} \bigg/ \frac{n A C \pi r}{B E}.$$

$$\text{„ } d_b = \frac{n i k}{j} \times \frac{B E}{n A C \pi r}.$$

$$\therefore d_b = \frac{i}{j} \cdot \frac{B E}{A C} \cdot \frac{k}{\pi r} \quad . \quad . \quad . \quad . \quad . \quad (3_b)$$

28. Having derived formulæ for total, front, and back drafts for gill boxes, the question is whether the sum or the product of front and back drafts is equal to total draft, this having been a source of much confusion.

Now  $d_b = \frac{v_2}{v}, \therefore v = \frac{v_2}{d_b},$

and  $d_f = \frac{V}{v_2}, \therefore V = d_f v_2.$

From (1)  $d = \frac{V}{v}.$

By substituting

$$d = \frac{d_f v_2}{v_2/d_b} = \frac{d_f v_2 d_b}{v_2} = d_f d_b.$$

Since  $d = d_b d_f \dots \dots \dots (3_b)$

Substituting in (3<sub>b</sub>) and (3<sub>f</sub>)

$$d = \frac{i}{j} \frac{B E}{A C} \frac{k}{\pi r} \times \frac{j}{i} \frac{\pi R}{k} \frac{g}{h}.$$

$$d = \frac{R B E}{r A C} \frac{g}{h} \dots \dots \dots (3)$$

Hence the total draft is equal to the **product** of back and front drafts.

Formula (3) is comprehensive, and covers the whole of draft race calculations.

29. Obtaining dimensions for draft race calculations is very simple. The spinning overlooker would require six particulars, which may be arranged as follows :—

R = 3 inches.

r = 1½ inches.

A = change wheel.

B = 100.

C = 68.

E = 100.

d = draft.

Now  $d = \frac{R B E}{r A C}.$

Then  $d = \frac{3 \times 100 \times 100}{1\frac{1}{2} A 68}.$

$\therefore d = 353/A.$

Let P = 353 = gauge point.

Then  $d = 353/A = P/A.$

Also  $A d = P. \quad A = P/d.$

Up to the present, "gauge point" has been refrained from, as experience proves that from master to apprentice the idea exists that gauge point is of the first importance, whereas it is the *draft* which contains the gauge point; consequently, any of the factors are usable as change wheels, either singly or in pairs.

30. *Example*.—A spinning frame has the following dimensions :—

Diameter of front roller = 2 inches.

Diameter of back roller =  $1\frac{1}{4}$  inches.

Draft wheel = 40 teeth.

Stud wheel = 50 „

Plate wheel = 20 „

*Question*.—Find draft.

*Solution*.—Using Formula (2),

$$d = \frac{R B E}{r A C} = \frac{2 \times 50 \times E}{1\frac{1}{4} \times 40 \times 20} = \frac{E}{10} = 0.1 E.$$

$$d = 0.1 E \text{ draft. } \textit{Ans.}$$

*Example*.—

Diameter of front roller =  $2\frac{1}{2}$  inches.

Diameter of back roller =  $1\frac{1}{2}$  inches.

Draft wheel = 40 teeth.

Stud wheel = 80 „

Plate wheel = 33 „

*Question*.—Find gauge point.

*Solution*.—Using Formula (2).

$$d = \frac{R B E}{r A C} = \frac{2\frac{1}{2} \times 80 \times E}{1\frac{1}{2} \times 40 \times 33} = \frac{10 E}{99} = 0.1 E.$$

$$P = 0.1 \text{ gauge point. } \textit{Ans.}$$

The three following tables are derived from Formulæ 2 and 3, and are arranged in the order of magnitude of "P."

In Table II., No. 16, and in Table III., No. 10, the lines stated average, respectively, the lines which precede them.

SECTION 31. TABLE I.

No.	R	r	A	B	C	E	P
1	2	1 $\frac{1}{4}$	40	50	20	x	0.1
2	3	2	60	x	36	144	0.1
3	3	2	51	x	42	144	0.1
4	2 $\frac{1}{2}$	2	58	x	31	144	0.1
5	3	2	40	x	37	100	0.1
6	2 $\frac{1}{2}$	2	48	x	37	144	0.1
7	2 $\frac{1}{2}$	2	28	x	44	100	0.1
8	2 $\frac{1}{2}$	1 $\frac{1}{2}$	40	80	33	x	0.1
9	4	2 $\frac{1}{2}$	x	100	83	83	160
10	4	2 $\frac{1}{2}$	x	None.	None.	100	160
11	3 $\frac{1}{2}$	2 $\frac{1}{2}$	x	67	56	100	168
12	3	2	x	100	84	100	179
13	4	2	x	90	100	100	180
14	3	2	x	100	83	100	181
15	4	2 $\frac{5}{8}$	x	100	83	100	184
16	4	2 $\frac{1}{2}$	x	100	83	100	193
17	4	2 $\frac{1}{2}$	x	100	58	70	193
18	4	2 $\frac{1}{2}$	x	100	81	100	199
19	3	2	x	72	54	100	200
20	4	2	x	80	80	100	200
21	2 $\frac{1}{2}$	2	x	100	62	100	202
22	4	2 $\frac{1}{2}$	x	100	83	110	212
23	2 $\frac{1}{2}$	2 $\frac{1}{2}$	x	100	47	100	213
24	3	2 $\frac{1}{2}$	x	100	56	100	214
25	4	2 $\frac{1}{2}$	x	100	84	125	238
26	4	2	x	100	70	84	240
27	3	2	x	100	62	100	242
28	4	2	x	100	80	100	250
29	3	2 $\frac{1}{2}$	x	100	48	100	250
30	5	2 $\frac{1}{2}$	x	None.	None.	125	250
31	3	2	40	80	x	90	270
32	2 $\frac{1}{2}$	1 $\frac{1}{2}$	40	80	x	87	290
33	4	2	x	100	84	125	298
34	5	2	x	125	104	100	300
35	3	1 $\frac{1}{4}$	x	100	68	100	353
36	3 $\frac{7}{10}$	2	30	62	x	100	355
37	3 $\frac{1}{2}$	2	30	62	x	100	362
38	5	2	x	100	84	125	372
39	5	2 $\frac{1}{2}$	x	125	80	125	392



TABLE III.

SECTION 33.

No.	$\pi R$	$\pi r$	A	B	C	E	g	h	i	j	$k_i$	$d_0$	$d_1$	d	P
1	$8\frac{1}{2}$	$11\frac{1}{2}$	18	70	22	70	x	70	18	12	$\frac{5}{8}$	1.008	0.129g	0.130g	0.130
2	$8\frac{3}{8}$	$11\frac{5}{8}$	19	70	20	70	x	70	27	18	$\frac{5}{8}$	1.040	0.128g	0.133g	0.133
3	$8\frac{1}{2}$	$11\frac{3}{8}$	20	70	19	70	x	70	27	18	$\frac{5}{8}$	1.040	0.130g	0.135g	0.135
4	$8\frac{1}{2}$	$11\frac{1}{2}$	19	70	20	70	x	70	18	12	$\frac{5}{8}$	1.051	0.129g	0.136g	0.136
5	$9\frac{1}{2}$	$12\frac{1}{8}$	19	70	19	70	x	60	27	18	$\frac{5}{8}$	1.049	0.164g	0.172g	0.172
6	$8\frac{1}{2}$	$12\frac{1}{2}$	20	70	15	70	x	60	18	12	$\frac{1}{2}$	1.000	0.189g	0.189g	0.189
7	$8\frac{1}{2}$	$12\frac{3}{8}$	20	70	15	70	x	60	18	12	$\frac{1}{2}$	1.010	0.189g	0.191g	0.191
8	$8\frac{1}{2}$	$11\frac{1}{2}$	16	70	20	70	x	60	27	18	$\frac{1}{2}$	1.021	0.189g	0.193g	0.193
9	$9\frac{1}{2}$	11	21	70	15	70	x	60	18	12	$\frac{1}{2}$	1.060	0.211g	0.224g	0.224
10 (average).	$8\frac{1}{2}$	$11\frac{3}{8}$	$19\frac{1}{2}$	70	$18\frac{1}{2}$	70	x	$64\frac{5}{8}$	22	$14\frac{5}{8}$	$\frac{1}{2}$	1.024	0.158g	0.161g	0.161

34. A set of botany drawing consists of nine operations, which are as follows :—

- (1) Two double can gill boxes.
  - (2) Three two-spindle gill boxes.
  - (3) One six-spindle drawing box.
  - (4)        "               weigh box.
  - (5) One eight-spindle finishing box.
  - (6) Two eight-spindle second finishing boxes.
  - (7) Two twenty-and one ten-spindle first reducing boxes.
  - (8) Six second reducing boxes of two twenty-six  
spindles (8-inch  $\times$  4-inch bobbins) and four  
twenty-four spindles (7-inch  $\times$  4-inch bobbins).
  - (9) Twenty-four (24 to 42) spindle, roving boxes made  
by Prince Smiths, Hall and Stells, or Ramsden.
- Total available spindles, 768.

TABLE IV.

Operation.	Name.	No. of Spindles.
1st Operation.	2 double C. G. B.	4 ends.
2nd       "	3 2-Sp. G. B.	6 sp.
3rd       "	1 6-Sp. Drg. Bx.	6 sp.
4th       "	1 6-Sp. Wg. Bx.	6 sp.
5th       "	1 8-Sp. 1st F. Bx.	8 sp.
6th       "	2 8-Sp. 2nd F. Bx.	16 sp.
7th       "	2 20-Sp. and 1 10-Sp., 1st Redu. Bx.	50 sp.
8th       "	{ 2 26-Sp. (8 $\times$ 4), 4 24-Sp. (7 $\times$ 4), } 2nd Redu. Bx.	148 sp.
9th       "	24-(24-42) Sp. P. S., H. and S., and R. Rov. Bx.	768 sp.
9 Operations.	43 Boxes, with	1,008 spindles.

Table V. is intended for the purpose of arranging the dimensions in a set of drawing to enable one to find the unknown values of P and d.

TABLE V.

## SECTION 35.

Operation.	Name.	$\pi R$	$\pi r$	A	B	C	E	g	h	P	d
1	1st C.G.B.	$6\frac{1}{2}$	$3\frac{1}{2}\pi$	23	70	18	70	x	60	0.136	0.136g
1	2nd "	$6\frac{5}{8}$	$3\frac{3}{8}\pi$	23	70	19	70	x	60	0.126	0.126g
2	1st S.G.B.	$6\frac{5}{8}$	$3\frac{1}{2}\pi$	26	70	16	70	x	60	0.132	0.132g
2	2nd "	$6\frac{7}{8}$	$3\frac{3}{4}\pi$	26	70	16	70	x	60	0.137	0.137g
2	3rd "	$6\frac{3}{8}$	$12\frac{1}{2}$	21	70	15	70	x	60	0.128	0.128g
3	6, S.D.B.	4	$2\frac{1}{2}$	x	100	83	100			192	192/A
4	6, S.W.B.	4	$2\frac{1}{2}$	x	100	83	100			160	160/A
5	8 S., 1st F.B.	4	$2\frac{1}{2}$	x	100	83	100			192	192/A
6	1st 8 S., 2nd F.B.	4	$2\frac{1}{2}$	x	Minus.	Minus.	100			160	160/A
6	2nd "	4	$2\frac{1}{2}$	x	100	100	100			160	160/A
7	1st 20 S., 1st R.B.	4	2	x	100	83	100			241	241/A
7	2nd "	4	2	x	100	83	100			241	241/A
7	3rd 10 S., "	4	$2\frac{1}{2}$	x	100	67	100			241	241/A
8	6, 2nd R.B.	4	2	x	100	83	100			241	241/A
9	24 r.B.	4	2	x	100	83	100			241	241/A
9	" (contd.)	3	2	x	100	62	100			242	242/A



36. Calculations for :—

1st Operation, 1st C. G. B.

$$d = \frac{R B E}{r A C} \quad \frac{g}{h} = \frac{6\frac{3}{4}}{3\frac{1}{8} \times 3\frac{1}{7}} \quad \frac{70 \times 70}{23 \times 18} \quad \frac{g}{60}.$$

$$d = \frac{27}{4} \quad \frac{8}{25} \quad \frac{7}{22} \quad \frac{70 \times 70}{23 \times 18} \quad \frac{g}{60} = \frac{7 \times 7 \times 7}{55 \times 46} \quad g = 0.136g.$$

$$P = 0.136; \quad d = 0.136g.$$

2nd C. G. B.

$$d = \frac{R B E}{r A C} \quad \frac{g}{h} = \frac{6\frac{5}{8}}{3\frac{1}{7} \times 3\frac{1}{8}} \quad \frac{70 \times 70}{23 \times 19} \quad \frac{g}{60}.$$

$$d = \frac{53}{8} \quad \frac{7}{22} \quad \frac{8}{25} \quad \frac{70 \times 70}{23 \times 19} \quad \frac{g}{60} = \frac{7 \times 7 \times 7 \times 53}{55 \times 46 \times 57} \quad g = 0.126g.$$

$$P = 0.126; \quad d = 0.126g.$$

2nd Operation, 1st Sp. G. B.

$$d = \frac{R B E}{r A C} \quad \frac{g}{h} = \frac{6\frac{5}{8}}{3\frac{1}{8} \times 3\frac{1}{7}} \quad \frac{70 \times 70}{26 \times 16} \quad \frac{g}{60}.$$

$$d = \frac{53}{8} \quad \frac{8}{25} \quad \frac{7}{22} \quad \frac{70 \times 70}{26 \times 16} \quad \frac{g}{60} = \frac{7 \times 7 \times 7 \times 53}{55 \times 26 \times 96} \quad g = 0.132g.$$

$$P = 0.132; \quad d = 0.132g.$$

2nd Sp. G. B.

$$d = \frac{R B E}{r A C} \quad \frac{g}{h} = \frac{6\frac{7}{8}}{3\frac{1}{8} \times 3\frac{1}{7}} \quad \frac{70 \times 70}{26 \times 16} \quad \frac{g}{60}.$$

$$d = \frac{55}{8} \quad \frac{8}{25} \quad \frac{7}{22} \quad \frac{70 \times 70}{26 \times 16} \quad \frac{g}{60} = \frac{7 \times 7 \times 7}{26 \times 96} \quad g = 0.137g.$$

$$P = 0.137; \quad d = 0.137g.$$

3rd Sp. G. B.

$$d = \frac{R B E}{r A C} \quad \frac{g}{h} = \frac{6\frac{3}{8}}{12\frac{1}{16}} \quad \frac{70 \times 70}{21 \times 15} \quad \frac{g}{60}.$$

$$d = \frac{51}{8} \frac{16}{207} \frac{70 \times 70}{21 \times 15} \frac{g}{60} = \frac{17 \times 2 \times 7}{207 \times 9} g = 0.128g.$$

$$P = 0.128; d = 0.128g.$$

3rd Operation, 6 Sp. D. B. (using Formula (2)).

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2\frac{1}{2} \times A \times 83} = \frac{192}{A} = \frac{P}{A}.$$

$$P = 192; d = 192/A.$$

4th Operation, 6 Sp. W. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 83}{2\frac{1}{2} \times A \times 83} = \frac{160}{A} = \frac{P}{A}.$$

$$P = 160; d = P/A.$$

5th Operation, 8 Sp., 1st F. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2\frac{1}{2} \times A \times 83} = \frac{192}{A} = \frac{P}{A}.$$

$$P = 192; d = P/A.$$

6th Operation, 1st 8 Sp., 2nd F. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times B \times 100}{2\frac{1}{2} \times A \times C} = \frac{160}{A} = \frac{P}{A}.$$

$$P = 160; d = P/A.$$

2nd 8 Sp., 2nd F. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2\frac{1}{2} \times A \times 100} = \frac{160}{A} = \frac{P}{A}.$$

$$P = 160; d = P/A.$$

7th Operation, 1st 20 Sp., 1st Redu. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2 \times A \times 83} = \frac{241}{A} = \frac{P}{A}.$$

$$P = 241; d = P/A.$$

2nd 20 Sp., 1st Redu. B.

Same dimensions as 1st above, hence same values for P and d.

3rd 10 Sp., 1st Redu. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2\frac{1}{2} \times A \times 67} = \frac{242}{A} = \frac{P}{A}.$$

$$P = 242 ; d = P/A.$$

8th Operation, 6 2nd Redu. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2 \times A \times 83} = \frac{241}{A} = \frac{P}{A}.$$

$$P = 241 ; d = P/A.$$

9th Operation, Rov. B.

$$d = \frac{R B E}{r A C} = \frac{4 \times 100 \times 100}{2 \times A \times 83} = \frac{241}{A} = \frac{P}{A}.$$

$$P = 241 ; d = P/A.$$

Rov. B. (contd.).

$$d = \frac{R B E}{r A C} = \frac{3 \times 100 \times 100}{2 \times A \times 62} = \frac{242}{A} = \frac{P}{A}.$$

$$P = 242 ; d = P/A.$$

## CHAPTER III

### MACHINES—TWIST.

37. On twisting, spinning frames (cap and flyer), and drawing boxes, except can gill boxes, are two trains of wheels or pulleys working in conjunction with each other. The first train is that which gives speed to spindles; the second train gives velocity to front rollers. These run simultaneously, the ratio of which call "T."

Letting  $S$  = speed of spindles or tubes per min.

And  $V$  = velocity of front roller in inches per min.

Then  $T = S/V$ . . . . . (4)

38. The **spinning frame** being the most important, the value of "T" will be found first for this.

Let  $n_c$  = r.p.m. of cylinder.

„  $d$  = diam. of tube or spindle whorl in inches.

„  $c$  = „ cylinder in inches.

„  $e$  = „ flange pulley or catch-box or number of teeth in wheel on cylinder shaft, which may be altered as a change pulley or wheel.

„  $f$  = „ twist pulley or number of teeth in large stud wheel.

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Let  $g$  = number of teeth in twist change wheel.

„  $h$  = „ „ roller end wheel, sometimes used as a change wheel.

„  $R$  = diameter of front roller in inches.

Then  $S = n_c \frac{c}{d}$  and  $V = n_c \frac{e g}{f h} \pi R$ .

Substituting in (4),

Then  $T = n_c \frac{c}{d} / n_c \frac{e g}{f h} \pi R$ ,

∴  $T = n_c \frac{c}{d} \times \frac{1}{n_c} \frac{f h}{e g} \frac{1}{\pi R}$ ,

∴  $T = \frac{c}{d} \frac{f h}{e g} \frac{1}{\pi R}$  . . . . . (5)

## 39. Twisting Frames.

Let  $n_c$  = r.p.m. of cylinder.

„  $c$  = diam. of cylinder in inches.

„  $d$  = „ tube or spindle whorl in inches.

„  $e$  = „ flange pulley or catch-box or number of teeth in wheel on cylinder shaft, which may be altered as a change pulley or wheel.

„  $f$  = „ twist pulley or number of teeth in stud wheel.

„  $g$  = number of teeth in twist change wheel.

„  $h$  = „ „ roller shaft wheel, sometimes used as a change wheel.

TABLE VI.

SECTION 40.

Name.	No.	c	d	e	f	g	h	i	j	$\pi R$	P	T
T.F.	1	11	1	10	6	x	84	2k	12	$2\frac{1}{8}\pi$	498.3	P/g
"	2	11	1	10	6	x	100	2k	12	$2\frac{1}{2}\pi$	504.1	P/g
"	3	10	1	8	6	x	88	2k	12	$2\frac{1}{2}\pi$	504.2	P/g
"	4	10	1	8	6	x	75	2k	12	$2\frac{1}{8}\pi$	505.6	P/g
S.F.	5	11	1	$7\frac{1}{2}$	18	x	268			4 $\pi$	544.8	P/g
"	6	10	1	7	18	x	268			4 $\pi$	548.3	P/g
"	7	10	1	$6\frac{1}{2}$	18	x	268			4 $\pi$	568.5	P/g
"	8	10	$\frac{2}{3}$	37	83	x	180			3 $\pi$	571.2	P/g

Let  $i$  = number of teeth in driving bevel wheel, or  
roller shaft wheel, or  
worm (usually double).

„  $j$  = „ „ driven bevel wheel for  
roller upright shaft.

„  $R$  = diameter of roller in inches.

Then  $S = n_c \frac{c}{d}$  and  $V = n_c \frac{e g}{f h} \frac{i}{j} \pi R$ ,

Substituting in (4) :—

Then  $T = n_c \frac{c}{d} \left/ n_c \frac{e g}{f h} \frac{i}{j} \right. \pi R$ ,

and  $T = n_c \frac{c}{d} \times \frac{1}{n_c} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}$ ,

$\therefore T = \frac{c}{d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}$ . . . . . (6)

The table on p. 29 has been constructed in the order of magnitude of  $P$ .

41. Commencing in the drawing with

### Roving and Reducing Boxes.

Let  $n_c$  = r.p.m. of cylinder shaft.

„  $c$  = diam. of band pulleys in inches.

„  $d$  = „ spindle whorl in inches.

„  $e$  = number of teeth in driving wheel on cylinder  
shaft end.

„  $f$  = „ „ driven large stud wheel.

„  $g$  = „ „ twist change wheel.

„  $h$  = „ „ front roller wheel, some-  
times used as a change  
wheel.

„  $R$  = diam. of front roller in inches.

Then  $S = n_c \frac{c}{d}$  and  $V = n_c \frac{e g}{f h} \pi R$ .

Substituting in (4),

Then  $T = n_c \frac{c}{d} / n_c \frac{e g}{f h} \pi R$ .

$$T = n_c \frac{c}{d} \times \frac{1}{n_c} \frac{f h}{e g} \frac{1}{\pi R}.$$

$$T = \frac{c}{d} \frac{f h}{e g} \frac{1}{\pi R}. \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad (7)$$

#### 42. Cone Roving, Reducing, and Drawing Boxes.

Let  $n_c$  = r.p.m. of first and main shaft.

„  $a$  = number of teeth in first driving wheel for spindles on first shaft.

„  $b$  = follower to “ $a$ ” in spindle train on spindle bevel wheel shaft.

„  $c$  = driving bevel wheel for spindle.

„  $d$  = driven bevel wheel on spindle shaft.

„  $e$  = twist change wheel on end of first shaft making  $n_c$  r.p.m.

„  $f$  = driven large stud wheel.

„  $g$  = driving small stud wheel.

„  $h$  = number of teeth in driven wheel on cone shaft.

„  $i$  = „ „ driving cone shaft wheel.

„  $j$  = „ „ driven roller end wheel.

„  $R$  = diam. of front roller in inches.

Then  $S = n_c \frac{a c}{b d}$  and  $V = n_c \frac{e g}{f h} \frac{i}{j} \pi R$ .



Substituting in (4).

$$\text{Then } T = n_c \frac{a c}{b d} \bigg/ n_c \frac{e g}{f h} \frac{i}{j} \pi R.$$

$$\text{and } T = n_c \frac{a c}{b d} \times \frac{1}{n_c} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\therefore T = \frac{a c}{b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

43. The spinning and twisting frames, open roving and reducing boxes, together with the cone roving, reducing, and drawing boxes, may be considered permanent spindle drives or constant speeds, which speeds are altered only by changing the size of driven pulley in the driving belt race; known wrongly as driving pulley.

It is in the second train of wheels where changes are made by altering the velocity of front roller with twist change wheel, *g* (invariably).

44. **Finishing and drawing boxes** are provided with a spindle change wheel, which is in the *first* train of wheels, thus leaving the driving roller wheel, "*g*," for speed instead of twist alterations. There are many boxes which have wheel or pulley, "*e*," attached to second instead of first shaft, as shown by the following, therefore placing them with those already studied.

Let  $n_c$  = r.p.m. of first shaft.

„  $a$  = number of teeth in driving wheel on first shaft.

„  $b$  = „ „ driven wheel on second shaft.

„  $c$  = diam. of driving pulley in inches on second shaft.



**46. Spindle Gill Boxes.**

Let  $n_c$  = r.p.m. of speed shaft.

„  $a_1$  = diam. of driving pulley in inches on speed shaft.

„  $b_1$  = „ driven spindle wheel pulley in inches.

„  $a$  = number of teeth in spindle wheel.

„  $b$  = „ „ driven wheel on back spindle shaft.

„  $c$  = diam. of driving spindle pulley in inches on back spindle shaft.

„  $d$  = „ spindle whorl in inches.

„  $e$  = number of teeth in speed wheel on end of speed shaft.

„  $f$  = „ „ driven wheel on back shaft.

„  $g$  = „ „ draft change wheel.

„  $h$  = „ „ front roller wheel.

„  $R$  = diam. of front roller in inches.

Then  $S = n_c \frac{a_1 a c}{b_1 b d}$ , and  $V = n_c \frac{e g}{f h} \pi R$ .

Substituting in (4).

Whence  $T = n_c \frac{a_1 a c}{b_1 b d} \cdot n_c \frac{e g}{f h} \pi R$ ,

and  $T = n_c \frac{a_1 a c}{b_1 b d} \times \frac{1}{n_c} \frac{f h}{e g} \frac{1}{\pi R}$ .

∴  $T = \frac{a_1 a c}{b_1 b d} \times \frac{f h}{e g} \frac{1}{\pi R}$ . . . . . (10)

**47. A comprehensive formula combining all twist wheel calculations is as follows :—**

$$T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R} \cdot \cdot \cdot \quad (11)$$

SECTION 48.

TABLE VII.

Name.	No.	a	b	c	d	e	f	g	h	i	j	$\pi R$	P	T
D.B.	1			9	3	12	12	x	180			4 $\pi$	42.96	P/g
R.B.	2			8 $\frac{1}{2}$	2 $\frac{1}{2}$	100	125	x	155			4 $\pi$	52.41	P/g
"	3			8	2	60	88	x	180			4 $\pi$	84.03	P/g
r.B.	4			8	2	40	66	x	180			4 $\pi$	94.54	P/g
"	5			26 $\frac{1}{2}$	7 $\frac{1}{2}$	60	125	x	180			4 $\pi$	108.00	P/g
"	6			29 $\frac{1}{2}$	7 $\frac{1}{2}$	60	100	x	180			3 $\pi$	128.40	P/g

SECTION 49.

TABLE VIII.

Name.	No.	a	b	c	d	e	f	g	h	i	j	$\pi R$	P	T
D.B.	1	40	58	37	35	x			35	24	85	3 $\frac{1}{2}\pi$	8.219	P/e
"	2	50	54	37	35	x			35	24	85	3 $\frac{1}{2}\pi$	11.03	P/e
W.B.	3	50	54	37	35	x			45	24	85	3 $\frac{1}{2}\pi$	14.19	P/e
F.B.	4	40	58	50	26	x	70	60	50	40	115	3 $\pi$	23.60	P/e
R.B.	5	60	58	50	26	x			52	42	115	3 $\pi$	30.06	P/e
"	6	60	58	50	26	x			55	53	115	2 $\frac{1}{2}\pi$	30.26	P/e
"	7	60	58	50	26	x			55	42	120	3 $\pi$	33.21	P/e
"	8	54	58	50	26	x	70	42	60	40	115	2 $\frac{1}{2}\pi$	54.61	P/e
r.B.	9	60	58	50	22	x	50	30	50	40	115	2 $\frac{1}{2}\pi$	71.74	P/e
R.B.	10	72	62	50	22	x	50	30	52	33	120	4 $\pi$	78.93	P/e
r.B.	11	60	50	50	22	x	55	34	50	40	115	2 $\frac{1}{2}\pi$	80.81	P/e
"	12	60	52	52	22	x	50	30	52	37	126	3 $\pi$	85.43	P/e
"	13	72	52	50	22	x	60	30	52	42	120	3 $\pi$	99.24	P/e

TABLE IX.

SECTION 50.

Name.	No.	a	b	c	d	e	f	g	h	i	j	$\pi R$	P	T
D.B.	1	35	x	7	6 $\frac{1}{2}$	11	9	x	155	x	x	4 $\pi$	380.3	P/b g
"	2	35	x	7	6 $\frac{1}{2}$	14	9	x	155	x	x	3 $\pi$	398.5	P/b g
W.B.	3	35	x	7	6 $\frac{1}{2}$	10	9	x	155	x	x	4 $\pi$	418.3	P/b g
D.B.	4	35	x	6 $\frac{3}{4}$	6 $\frac{1}{2}$	10	10	x	155	x	x	4 $\pi$	448.2	P/b g
"	5	35	x	8	6 $\frac{1}{2}$	10	9	x	125	x	x	3 $\pi$	484.8	P/b g
"	6	35	x	7	6 $\frac{1}{2}$	9	10	x	155	x	x	4 $\pi$	516.5	P/b g
"	7	35	x	5	6 $\frac{1}{2}$	14	14 $\frac{1}{2}$	x	180	x	x	3 $\pi$	532.6	P/b g
F.B.	8	35	x	5	6 $\frac{1}{2}$	13 $\frac{1}{2}$	12	x	180	x	x	2 $\frac{1}{2}\pi$	538.7	P/b g
D.B.	9	43	x	6 $\frac{3}{4}$	6 $\frac{1}{2}$	9	9	x	155	x	x	4 $\pi$	550.7	P/b g
"	10	35	x	8	6 $\frac{1}{2}$	9	9	x	125	x	x	3 $\pi$	571.4	P/b g
"	11	35	x	9	4 $\frac{1}{2}$	10	9	x	125	x	x	3 $\pi$	578.5	P/b g
"	12	35	x	9	4 $\frac{1}{2}$	13	9	x	125	x	x	3 $\pi$	642.7	P/b g
F.B.	13	39	x	6 $\frac{3}{4}$	4 $\frac{1}{2}$	9	9	x	155	x	x	4 $\pi$	721.4	P/b g
D.B.	14	35	x	7	6 $\frac{1}{2}$	13 $\frac{1}{2}$	12	x	180	x	x	2 $\frac{1}{2}\pi$	754.1	P/b g
"	15	35	x	7	6 $\frac{1}{2}$	11	14 $\frac{1}{2}$	x	180	x	x	3 $\pi$	773.4	P/b g
F.B.	16	35	x	9	4 $\frac{1}{2}$	11	9	x	180	x	x	4 $\pi$	820.4	P/b g
D.B.	17	35	x	7	4 $\frac{1}{2}$	14	12	x	180	x	x	2 $\frac{1}{2}\pi$	1,070.0	P/b g
"	18	35	x	7	4 $\frac{1}{2}$	12 $\frac{1}{2}$	14 $\frac{1}{2}$	x	180	x	x	3 $\pi$	1,206.0	P/b g

TABLE X.

SECTION 51.

Name.	No.	a <sub>1</sub>	b <sub>1</sub>	a	b	c	d	e	f	g	h	$\pi R$	P	T
S.G.B.	1	9	9	x	60	4 $\frac{1}{2}$	6 $\frac{1}{2}$	x	70	x	60	7	7.50	P a/c g
"	2	9	6 $\frac{1}{2}$	x	60	4 $\frac{1}{2}$	6 $\frac{1}{2}$	x	70	x	60	2 $\frac{1}{2}\pi$	10.89	P a/e g
"	3	9	6 $\frac{1}{2}$	x	60	4 $\frac{1}{2}$	6 $\frac{1}{2}$	x	70	x	60	6 $\frac{1}{2}$	11.19	P a/e g
"	4	10	6 $\frac{1}{2}$	x	60	5	6 $\frac{1}{2}$	x	70	x	60	7	11.83	P a/e g
"	5	13 $\frac{1}{2}$	6 $\frac{1}{2}$	x	60	5	6 $\frac{1}{2}$	x	70	x	60	2 $\frac{1}{2}\pi$	16.75	P a/e g

By substituting the numerical values of these letters, the ratio "T" may be found on **any** frame or box.

Tables VII., VIII., IX., and X. (pp. 35 and 36) have been worked out by using formula (11).

### WORKED-OUT EXAMPLES.

**52. A twisting frame** has the following dimensions. It is required to find the ratio of T and value of P.

Diameter of roller,  $2\frac{1}{8}$  inches ; number of teeth in roller spindle wheel, 12 ; worm on roller shaft, double ; roller end wheel, 81 teeth ; diameter of twist pulley,  $6\frac{1}{2}$  inches ; diameter of cylinder pulley or catch box,  $10\frac{1}{2}$  inches ; diameter of cylinder, 11 inches ; diameter of tube whorl, 1 inch.

Then  $R = 2\frac{1}{8}$  ;  $j = 12$  ;  $i = 2$  ;  $h = 81$  ;  $f = 6\frac{1}{2}$  ins. ;  $e = 10\frac{1}{2}$  ;  $d = 1$  in. ; and  $c = 11$  ins.

$$\text{By (11)} \quad T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\text{Then} \quad T = \frac{11}{1} \frac{6\frac{1}{2} \times 81}{10\frac{1}{2} \times g} \frac{12}{2} \frac{1}{2\frac{1}{8} \times \pi},$$

$$\text{and} \quad T = \frac{496}{g} = \frac{P}{g}.$$

$$\text{Hence} \quad P = 496 ; T = P/g.$$

**53. A spinning frame** has the following particulars :—

$R = 3$  ;  $h = 180$  ;  $f = 87$  ;  $e = 39$  ;  $d = \frac{3}{4}$  ;  $c = 10$ .

Find values of T and P.

$$\text{By (11)} \quad T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\text{Then } T = \frac{10}{\frac{3}{4}} \frac{87 \times 180}{39 \times g} \frac{1}{3 \pi},$$

$$\text{and } T = \frac{567.9}{g} = \frac{P}{g}.$$

$$\therefore P = 567.9; T = P/g.$$

54. **A roving box** has the following dimensions :—

Find  $T$  and  $P$ .

$$c = 8\frac{1}{2}; d = 2\frac{1}{2}; e = 90; f = 120; h = 155; R = 4.$$

$$\text{Then } T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\text{and } T = \frac{8.5}{2.5} \frac{120 \times 155}{90 \times g} \frac{1}{4 \pi},$$

$$\therefore T = \frac{17 \times 31}{3 \times \pi \times g}.$$

$$T = \frac{55.91}{g} = \frac{P}{g}.$$

$$\therefore P = 55.91; T = P/g.$$

55. **A finishing box**, the particulars of which are :—

$$a = 35; c = 6.75; d = 6.5; e = 9.5; f = 9.25; h = 155; \text{ and } R = 4.$$

Find the value of  $T$  and  $P$ .

$$\text{Let } T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\text{Hence } T = \frac{35 \times 6.75}{b \times 6.5} \frac{9.25 \times 155}{9.5 \times g} \frac{1}{4 \pi}.$$

$$\text{and } T = \frac{436.4}{b g} = \frac{P}{b g},$$

$$\therefore P = 436.4, \text{ and } T = P/bg.$$

56. **A drawing box**, the dimensions of which are :—

$a = 35$  ;  $c = 6\frac{7}{8}$  ;  $d = 4\frac{3}{4}$  ;  $e = 11\frac{1}{4}$  ;  $f = 12\frac{1}{2}$  ;  $h = 155$  ;  
and  $R = 4$ .

Find the values of  $P$  and  $T$ .

$$\text{Then } T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\text{and } T = \frac{35 \times 6}{b \times 4\frac{3}{4}} \frac{12\frac{1}{2} \times 155}{11\frac{1}{4} \times g} \frac{1}{4 \pi}.$$

$$\text{Now } T = \frac{35}{b} \frac{55}{8} \frac{4}{19} \frac{25}{2} \frac{4}{45} \frac{155}{g} \frac{1}{4 \pi}.$$

$$\text{Hence } T = \frac{385 \times 25 \times 155}{684 \times \pi b \times g},$$

$$\text{and } T = \frac{693 \cdot 6}{b g} = \frac{P}{b g}.$$

$$\therefore P = 693 \cdot 6 ; \text{ and } T = P/b g.$$

57. **A spindle gill box** has a  $13\frac{3}{4}$ -inch pulley on 1st or speed wheel shaft driving by means of a belt, a  $6\frac{1}{2}$ -inch pulley with a stud for a change wheel attached. This gears into a wheel 60 teeth on end of low cylinder shaft, with pulley, the dimensions of which are  $6\frac{7}{8}$  inches, from which a small strap  $1\frac{1}{2}$  inches wide drives a spindle whorl, diameter of which is  $6\frac{1}{2}$  inches. The circumference of roller, 7 inches ; a speed wheel “ $e$ ” on first or speed shaft gears into a wheel of 70 teeth on back shaft, to which is attached the draft and change wheel “ $g$ ,” which gears by means of two idle or intermediate wheels into a wheel of 60 teeth on front roller shaft end.



Find the ratio T and gauge point P.

Hence  $a_1 = 13.75$ .

$b_1 = 6.5$ .

$a =$  change spindle wheel.

$b = 60$  teeth.

$c = 6.875$ .

$d = 6.5$ .

$\pi R = 7$ .

$e =$  speed change wheel.

$f = 70$  teeth.

$g =$  draft change wheel.

$h = 60$  teeth.

Whence  $T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}$ .

Then  $T = \frac{13.75 \times a \times 6.875}{6.5 \times 60 \times 6.5} \frac{70 \times 60}{e \times g} \frac{1}{7}$ .

$\therefore T = \frac{22.38a}{e g} = \frac{P a}{e g}$ .

$P = 22.38$  ;  $T = P a / e g$ .

**58. A cone roving box** has the following dimensions for the spindle train:—Keyed wheel on 1st and main shaft 45 teeth, driving by means of two intermediates a wheel of 62 teeth on end of bevel wheel shaft for spindles. On this shaft is a bevel wheel of 52 teeth gearing into and driving spindle bevel wheel of 26 teeth. For the velocity train of front rollers, a twist change wheel, “e,” attached to end of first main shaft drives stud wheels 59 and 29 teeth, the 29-wheel gearing into a wheel of 53 teeth on cone shaft, on the end of which is

a wheel of 39 teeth gearing into and driving a wheel of 51 teeth, known as roller end wheel.

Diameter of front roller is 3.5 inches.

Find the value of  $T$  in terms of  $P$ .

$a = 45$ ;  $b = 62$ ;  $c = 52$ ;  $d = 26$ ;  $e =$  twist change wheel;  $f = 59$ ;  $g = 29$ ;  $h = 53$ ;  $i = 39$ ;  $j = 51$ ; and  $\pi R = 3.5 \pi$ .

$$\text{Whence } T = \frac{a_1 a c}{b_1 b d} \frac{f h}{e g} \frac{j}{i} \frac{1}{\pi R}.$$

$$\text{Then } T = \frac{45 \times 52}{62 \times 26} \frac{59 \times 53}{e \times 29} \frac{51}{39} \frac{1}{3.5 \pi}.$$

$$\therefore T = \frac{18.61}{e} = \frac{P}{e}.$$

$$P = 18.61; T = P/e.$$

## CHAPTER IV.

**MACHINES—SPEEDS.**

**59. Twisting, Spinning, Cone, and Open Drawing.**—In order to derive formulæ for speeds of tubes and spindles, new letters will be introduced in addition to those already defined in the two previous chapters on draft and twist. Nothing will be stated as to the best speeds at which to run these spindles and tubes. In the introduction, the value, “*e*,” of **any** train of wheels or pulleys in general is given. The particularising and finding a comprehensive formula to cover the whole argument suitable for the manager and overlooker remains. There is **always** one line shaft with a drum attached thereto—also there may be several counter-shafts with drums, the consideration of which is left for the reader.

Let  $n_s$  = r.p.m. of line shaft.

„  $D$  = diam. of drum on line shaft in inches.

„  $F$  = „ driven pulley on end of cylinder or  
frame or box.

Now  $D$  (drum) is generally set by the engineer.

$n_s$  depends upon the speed of engine under engineer's control, but

$F$  is supplied by machine maker with the machine, which may be altered by the management according to requirements.

TABLE XI.

SECTION 60.

Name.	No.	$n_1$	D	F	$a_1$	$b_1$	$a$	$b$	$c$	$d$	S	P
S.G.B.	1	200	16	12	10	9	$a$	60	5	$6\frac{1}{2}$	P a	3,134
"	2	150	18	14	$13\frac{1}{2}$	$6\frac{1}{2}$	$a$	60	5	$6\frac{1}{2}$	P a	5,136
C.r.B.	3	250	20	15			72	52	50	22	1,049	
D.B.	4	140	18	14			35	$b$	$6\frac{1}{2}$	$6\frac{1}{2}$	P/b	6,805
F.B.	5	160	18	13			35	$b$	7	$6\frac{1}{2}$	P/b	8,364
D.B.	6	150	18	10			35	$b$	$6\frac{1}{2}$	$6\frac{1}{2}$	P/b	9,815
F.B.	7	155	18	13			35	$b$	$6\frac{1}{2}$	$4\frac{1}{2}$	P/b	10,443
"	8	156	18	17					9	3	495	
R.B.	9	245	20	22					8	2	891	
r.B.	10	210	20	12					8	2	1,400	
T.F.	11	210	54	21					10	1	5,400	
S.F.	12	234	48	20					10	1	5,316	
T.F.	13	210	54	20					10	1	5,670	
"	14	234	40	16					10	1	5,850	
S.F.	15	234	36	14					10	1	6,017	
"	16	210	48	22					10	1	6,109	
"	17	210	48	18					11	1	6,160	
T.F.	18	234	48	20					11	1	6,177	
S.F.	19	210	54	20					11	1	6,237	
"	20	234	48	18					10	1	6,240	
"	21	234	54	22					11	1	6,318	
"	22	234	54	20					10	1	6,318	
T.F.	23	234	40	16					11	1	6,435	

#### 44 WORSTED DRAWING AND SPINNING CALCULATIONS.

Let  $n_o =$  r.p.m. of cylinder or shaft in machine.

$$\text{Then } n_c = n_s \frac{D}{F} = n_s \frac{D}{F}. \quad \dots \dots \dots (12)$$

The value of  $n_s$  may be counted and calculated. In the twist gearing calculations of the former chapter, the value of  $S$  was found, the most comprehensive of which was that for a spindle gill box, as follows :—

$$S = n_c \frac{a_1}{b_1} \frac{a}{b} \frac{c}{d} = \text{first part of formula (10)}. \quad (10_1)$$

Substituting 12 in (10<sub>1</sub>).

$$\text{Then } S = n_s \frac{D}{F} \frac{a_1}{b_1} \frac{a}{b} \frac{c}{d}. \quad \dots \dots \dots (13)$$

Formula (13), being comprehensive, covers the whole series of factors for the calculation of speeds of tubes and spindles in drawing, spinning, and twisting.

The table on p. 43 is calculated by substituting numerical values given for factors in (13), and is arranged in the order of magnitude of  $S$ .

#### WORKED-OUT EXAMPLES.

**61. Twisting Frame.**—A line shaft making 220 r.p.m. with a drum attached of 48 inches diameter, which by means of a belt drives the cylinder of a twisting frame on which is a pulley of 14 inches. Diameter of cylinder is 10 inches, and that of the tube whorl 1 inch.

Find the value of  $S$ .

Solution :—

$$\text{By (13) } S = n_s \frac{D}{F} \frac{a_1}{b_1} \frac{a}{b} \frac{c}{d}.$$

$$(n_s = 220 ; D = 48 ; F = 14 ; c = 10 ; d = 1.)$$

$$\text{Then} \quad S = \frac{220 \times 48 \times 10}{14 \times 1} = 7,542.$$

$$\therefore \quad S = 7,542 \text{ r.p.m.} \quad \text{Ans.}$$

A *drawing box* has the following dimensions for spindle speed :— $n_s = 120$  ;  $D = 18$  ;  $F = 14$  ;  $a = 35$  ;  $c = 6\frac{1}{2}$  ; and  $d = 6\frac{1}{2}$ .

Find value of  $S$ .

$$\text{By (13)} \quad S = n_s \cdot \frac{D}{F} \cdot \frac{a_1 a c}{b_1 b d}.$$

$$\text{Hence} \quad S = 120 \cdot \frac{18}{14} \cdot \frac{35}{b} \cdot \frac{6.5}{6.5} = \frac{5,400}{b}.$$

$$\therefore \quad S = \frac{5,400}{b} = \frac{P}{b}.$$

$$P = 5,400, \text{ and } S = P/b.$$

A *spindle gill box* has the dimensions as follows for spindle speed train :—

$n_s = 160$  ;  $D = 20$  ;  $F = 16$  ;  $a_1 = 12$  ;  $b_1 = 10$  ;  $b = 60$  ;  $c = 5$  ; and  $d = 6$ .

Find the value of  $S$ .

$$\text{By (13)} \quad S = n_s \cdot \frac{D}{F} \cdot \frac{a_1 a c}{b_1 b d}.$$

$$\text{Then} \quad S = 160 \cdot \frac{20}{16} \cdot \frac{12}{10} \cdot \frac{a}{60} \cdot \frac{5}{6} = \frac{10a}{3}.$$

$$\therefore \quad S = 3.3\dot{a} = P a.$$

$$P = 3.3\dot{a}, \text{ and } S = P a.$$

With these three worked-out examples, together with Table XI., the reader will have little difficulty in speed calculations.

## CHAPTER V.

**MACHINES—KNOCKER-OFF MOTION.**

62. The subject of the **knocker-off motion** is one which is, perhaps, the least understood, consequently the actual working advantages of this train of wheels are lost. There is more than one firm whose K.O. motions are lying idle, especially on the reducing and roving boxes, including spinning frames. In one sense, **every** machine in both drawing and spinning may be looked upon as a measuring machine, and not only so, but the author believes that a whole set of drawing may be governed by this motion when some master-mind with an elasticity to control practical manipulations gives the desired result. The force of the above statement will be realised when dealing with weight per doff or bobbin in a later chapter. For the present K.O. motion is presented on the lines of the former chapter, thus deriving a comprehensive formula which may be used later as the occasion arises.

63. There are two types of K.O. motions known, respectively, in the trade, as the "three" and "five" wheel. The former is used on gill, reducing, and roving boxes, and on spinning frames with a slightly different method of presentation, while the latter is used on drawing boxes only. For the three-wheel motion the stopping of the machine depends upon two pegs fixed in the last

two wheels which meet and consequently press out the last wheel on its stud, thereby releasing a spring which acts on the stop-rod. As to *how often* these last two wheels meet depends upon the L.C.M. of the numbers of teeth in these wheels, which, for spinning, are usually 29 and 40, the 40 being the last wheel in the train, hence the 29 wheel will make 40 revolutions.

64. Let  $N_r$  = total number of revolutions of F.R. to cause peg wheels to meet on spinning frame.

„  $a$  = 1st kind of worm—double or single on F.R.

„  $b$  = number of teeth on 1st worm wheel on oblique shaft.

The above results in the revolutions of the oblique shaft on the other end of which is a worm, and therefore :—

Let  $c$  = 2nd kind of worm—double or single—on oblique shaft.

„  $d$  = change wheel (K), 1st stud wheel.

„  $e$  = number of teeth in 1st peg stud wheel.

„  $f$  = „ „ 2nd peg wheel, the last in the train ; also revs. of wheels “  $d$  ” and “  $e$  .”

Sometimes the 40-wheel, “  $f$ ,” has *two* pegs, and has occasionally been made with *four* pegs. The reason for this will be apparent on finding the L.C.M.

$$\text{Then } N_r \frac{a c}{b d} = f. \quad \therefore N_r = \frac{b d}{a c} f. \quad . \quad . \quad . \quad (14)$$



Now "a" is usually double worm, hence "a" equals 2. And "c" is usually double worm, hence "c" = 2; and "b" is generally 12 teeth, therefore "b" = 12.

Calling "d" "K," K.O. change wheel in this formula acts as an indicator as to what train of wheels is under consideration, the letters having been used previously in twist and speed train of wheels.

Now "f" = 40 or  $40/2 = 20$ .  $40/4 = 10$ , according to number of pegs attached.

Substituting in (14) :—

$$N_r = \frac{b d}{a c} f = \frac{12 \times K \times 40}{2 \times 2} = 120 K. \quad (15)$$

$$\text{And } K = N_r/120. \quad (16)$$

Now  $n_r$  = r.p.m. of F.R.

And let  $t$  = number of minutes to perform  $N_r$ , the total number of revolutions of F.R., per doff or weight required.

$$\text{Then } N_r/n_r = t. \quad (17)$$

65. This formula is very useful. The value of  $N_r$  is a *true mechanical record* of the revolutions per doff. By starting a spinning frame on the minute mark of one's watch, say 9.20, when, of course, the K.O. motion is set ready with peg wheels in position, then, at the same time, the value of  $n_r$  may be found by timing the revolutions of F.R. over one or more minutes. The writer usually counts over a number of minutes sufficient for the last count of  $n_r$  to be exactly, or nearly so, on the mark of a minute of his watch. Commencing at count 0 on 9.20, suppose one counts 47 and a fraction, the counts should be continued to the next minute—94 and a greater fraction—continuing to the third and fourth

minute, the latter being 189, when 9.24 will be recorded. Now,  $189/4$  equals  $47\frac{1}{4}$  r.p.m. Arranging as follows :—

Finished at 10.36 or F at 10.36,	Column 1
Started at 9.20 or S at 9.20,	2
Add value of $t_r$ , 1.16,	3
To Column 2 and fill in total 10.36 in	1
By transposition in (17) $N_r = n_r t$ .	
But by (15) $N_r = 120 K$ .	

**Hence**  $n_r t = 120 K$ . . . . (18)

*Example.*—Let  $K = 30$ , and  $t = 76$ .

Find  $n_r$ .

Substituting and transposing in (18)

$$n_r = 120 \times 30/76 = 47.3 \text{ r.p.m. } \textit{Ans.}$$

This agrees with the test. All that is required is for one to be in attendance at 10.35 to ascertain the exact time the frame stops due to K.O. motion.

66. **Gill reducing and roving boxes** have the same type of K.O. motion.

Let  $N_r = \text{total number of revolutions of F.R. to cause}$   
peg wheels to meet and consequently stop box.

„  $n_r =$  r.p.m. of F.R.

„  $a =$  kind of worm—usually single on F.R.

„  $b =$  number of teeth in change wheel K driven by  $a$ . This causes small upright sleeve to revolve at the other end, and at the base of which is a peg wheel  $c$ , usually 29 teeth, which gears into stop wheel  $d$ , the value of which varies. The revolutions of upright sleeve, on which is fastened K and  $c$ , are usually equal to number of teeth in  $d$ .

**Now**  $N_r a/b = d$ . . . . (19)

But  $a = 1$  single worm, and  $b = K$ .

$$N_r = d K. \quad . \quad . \quad . \quad . \quad . \quad (19_1)$$

Substituting (17) in (19<sub>1</sub>)

$$n_r t = d K.$$

$$t = d K / n_r. \quad . \quad . \quad . \quad . \quad . \quad (20)$$

This may be tested in the same way as the one on spinning frame previously given.

*Example.*—An actual test made October 24th, 1917, on a can gill box, where  $d = 39$ ;  $K = 41$ ; and  $n_r = 140$ .

Find the value of  $t$ .

Substituting in (20),  $t = 39 \times 41 / 140 = 11.4$  mins. *Ans.*

C.G.B. started at 2.40, finished at 2.51½, ∴ time run, 11½ minutes.

**67. On drawing boxes** the 5-wheel K.O. notice should be taken that whatever the train of wheels is the last wheel has attached, a peg or stud, which engages a catch, attached to the spring which actuates the stop-rod, when released. This takes place at each revolution of stop wheel.

Let  $N_r =$  total number of revolutions of F.R. in order to move stop wheel one revolution and thereby stop box.

„  $a =$  1st kind of worm, which drives wheel  $b$ .

„  $b =$  worm wheel usually 17 teeth.

„  $c =$  2nd kind of worm on worm shaft.

„  $d =$  number of teeth in large stud wheel, usually 60.

„  $e =$  „ „ small stud wheel ( $K =$  change wheel).

„  $f =$  „ „ stop wheel (number of teeth, 60 or 70).

$$\text{Then} \quad N_r \frac{a}{b} \frac{c}{d} \frac{e}{f} = 1. \quad (21)$$

$$\text{,,} \quad N_r = \frac{b d f}{a c K}. \quad (22)$$

$$\text{and} \quad K = \frac{b d f}{a c N_r}. \quad (23)$$

Substituting (17) in (22).

$$\text{Then} \quad n_r t = \frac{b d f}{a c K}. \quad (24)$$

$$\text{,,} \quad t = \frac{b d f}{a c K n_r}. \quad (24)$$

68. A test made on a finishing box, the given values of which are  $a = 1$ ,  $b = 17$ ,  $c = 1$ ,  $d = 60$ ,  $K = 37$ , and  $f = 60$ .

Counting revolutions of F.R. gave 78 r.p.m. (approximately).

$$\text{Then} \quad t = \frac{17 \times 60 \times 60}{1 \times 1 \times 37 \times 78} = 20.7. \quad \text{Ans.}$$

Time started, 6.42; time finished, 7.2½—therefore, time run, 20½ minutes.

To obtain the concrete value of  $N_r$  is not necessary, and in calculating the value of  $n_r$  from line shaft, or from cylinder shaft, is quite unnecessary. In order to count the r.p.m. of F.R. is simple and certain, and more especially when this result can be checked as in the examples given.

69. The following artifice is useful to find  $n_r$  in terms of twist wheel. Let the twist wheel be 50 teeth for 78 r.p.m. Let  $c = \text{constant}$ ;

$$\text{Then} \quad 50c = 78; \quad c = 1.56; \quad g = \text{twist wheel.}$$

$$\text{,,} \quad gc = n_r.$$

$$\text{,,} \quad n_r = 1.56g \text{ for this particular machine.}$$

TABLE XII.

SECTION 70.

Name.	No.	a	b	c	d	e	f	N <sub>R</sub>	t	K
S.F.	1	2	12	2	K	e	40	120K	N <sub>R</sub> /n <sub>R</sub>	N <sub>R</sub> /120
"	2	2	12	2	K	e	20	60K	"	N <sub>R</sub> /60
Various D	3	1	K	c	39			39K	"	N <sub>R</sub> /d
"	4	1	K	c	41			41K	"	"
"	5	1	K	c	59			59K	"	"
"	6	1	K	c	60			60K	"	"
"	7	1	K	c	61			61K	"	"
"	8	1	K	c	80			80K	"	"
"	9	1	K	c	81			81K	"	"
D.B.	10	1	17	1	60	K	70	17 × 60 × 70/K	"	b d / N <sub>R</sub>
"	11	1	17	1	60	K	60	17 × 60 × 60/K	"	"
"	12	1	19	1	60	K	60	19 × 60 × 60/K	"	"
"	13	1	21	1	60	K	60	21 × 60 × 60/K	"	"
"	14	1	22	1	60	K	60	22 × 60 × 60/K	"	"
"	15	1	23	1	60	K	60	23 × 60 × 60/K	"	"
"	16	1	24	1	60	K	60	24 × 60 × 60/K	"	"

## CHAPTER VI.

**MACHINES—LIFTER MOTION SPEEDS.****71. Spindle Gill Boxes.**

Let  $L_p$  = number of lifter picks per minute.

„  $n_s$  = „ r.p.m. of speed shaft.

„  $a_1$  = diameter in inches of pulley on speed shaft.

„  $b_1$  = diameter in inches of driven spindle pulley.

„  $a$  = number of teeth in spindle change wheel.

„  $b$  = „ „ driven wheel on spindle shaft.

„  $m$  = diameter in inches of pulley on spindle shaft.

„  $n$  = diameter in inches of driven lifter pulley.

„  $o$  = number of teeth in lifter change wheel.

„  $p$  = „ „ driven wheel on star wheel shaft.

„  $s$  = „ „ star wheel.

„  $t$  = „ „ mangle wheel.

$$\text{Then } L_p = n_s \left( \frac{a_1}{b_1} \frac{a}{b} \right) \left( \frac{m}{n} \frac{o}{p} \frac{s}{t} \right). \quad (25)$$

**72. Open Drawing Boxes.**

Let  $L_p$  = number of lifter picks per minute.

„  $n_s$  = „ r.p.m. of speed shaft.

„  $a$  = „ teeth in driving wheel on speed shaft.

„  $b$  = „ „ driven spindle change wheel.

Let  $m$  = diameter in inches of pulley on spindle shaft.

„  $n$  = diameter in inches of driven lifter pulley.

„  $o$  = number of teeth in lifter change wheel.

„  $p$  = „ „ driven large stud wheel.

„  $q$  = „ „ driving small stud wheel.

„  $r$  = „ „ driven wheel on star shaft.

„  $s$  = „ „ star wheel.

„  $t$  = „ „ mangle wheel.

$$\text{Then } L_p = n_s \frac{a}{b} \left( \frac{m}{n} \frac{o}{p} \frac{q}{r} \frac{s}{t} \right). \quad . \quad . \quad . \quad (26)$$

### 73. Open Finishing, Reducing, and Roving Boxes.

Let  $L_p$  = number of lifter picks per minute.

„  $n_c$  = „ r.p.m. of cylinder shaft.

„  $m$  = diameter in inches of driving pulley on cylinder shaft.

„  $n$  = diameter in inches of driven lifter pulley.

„  $o$  = number of teeth in lifter change wheel.

„  $p$  = „ „ driven large stud wheel.

„  $q$  = „ „ driving small stud wheel.

„  $r$  = „ „ driven wheel on star shaft

„  $s$  = „ „ star wheel.

„  $t$  = „ „ mangle wheel.

$$\text{Then } L_p = n_c \left( \frac{m}{n} \frac{o}{p} \frac{q}{r} \frac{s}{t} \right). \quad . \quad . \quad . \quad (27)$$

74. For open drawing boxes, the *practical* value  $L_p$  should be such as to allow the outside layers of sliver to be placed parallel on the bobbin—to calculate this value is useless. The three formulæ (25), (26), and (27) serve the purpose of showing the relationship of the various factors involved.

By combining formulæ (25), (26), and (27), a comprehensive formula is derived which will cover and include the value  $L_p$  on *all open* spindle gill, drawing, finishing, reducing, and roving boxes.

$$\text{Hence} \quad L_p = n_c \cdot \frac{a_1}{b_1} \cdot \frac{a}{b} \left( \frac{m}{n} \cdot \frac{o}{p} \cdot \frac{q}{r} \cdot \frac{s}{t} \right). \quad (28)$$

75. The length of lifter pick is governed by and is equal to the inside filling length of bobbin, and is a permanent form. On the spindle gill and drawing boxes the lifter plate is attached to a rack moved up and down by a pinion on the mangle wheel shaft, first in one direction and then in the other. Mangle wheels have their teeth in the form of pegs *on one side only* instead of on the edge of the rim: two solid rings parallel with the teeth running round the wheel, but leaving a channel in which the end of the star wheel shaft works. The star wheel containing 4 or 5 teeth gears into the pegs of the mangle wheel, secured down on its bearing by a cap, under which is room sufficient to allow the shaft to move horizontally, nearly 1 inch to one side or the other, but not vertically, so that when the end of the groove approaches, the wheel automatically turns over the last peg in considerably less than a revolution, until it is on the opposite side, thus enabling it to turn the mangle wheel and its shaft, to which is attached rack wheel, which gears into rack in an opposite direction. Notice should be taken of the fact that the star wheel and its shaft always revolve in one and the same direction, as the rack wheel makes practically one revolution in one direction and then reverses, thus giving the pick of lifter.



76. Let  $L_b$  = inside filling length of bobbin in inches.

„  $y$  = number of teeth in rack wheel.

„  $z$  = number of teeth in rack attached to lifter plate moved.

„  $p_r$  = pitch of teeth in rack wheel and rack.

Then  $y p_r = z p_r = L_b$ . . . . . (29)

Let  $L_b = 14$  inches, and  $p_r = \frac{3}{8}$  inch. (Note  $y = z$ , and  $p_r$  common to both.)

Then  $y \frac{3}{8} = 14$ ,  $\therefore y = 14 \times \frac{8}{3} = 112/3 = 37$  teeth. *Ans.*

From the above it can clearly be seen that the rack wheel in making one revolution moves the lifter rack 37 teeth, which picks a distance of 14 inches, the inside filling length of bobbin. It should be further noticed that the factors “ $a$ ” and “ $b$ ” in (28) also appear in the twist formula (11), hence the value  $L_2$  will alter as “ $a$ ” directly and “ $b$ ” inversely.

77. **On the finishing, reducing, and roving boxes,** instead of a rack wheel attached to the mangle wheel shaft, is a small pulley or bush, the motion of which is governed, as already explained, as it pays out and winds up, alternately, a chain attached to the lifter rail.

There are usually two diameters in steps in these pulleys, thereby enabling the chain to be attached to one or the other, according to length required to be paid out or wound up. By this means, and with the same kind of motion, known as “Mangle Wheel Motion,” a smaller-sized bobbin may be used if required, as is frequently the case. A reducing box may be used as a roving box. Both the larger and smaller boxes depend on the mangle wheel for the rapid reversal and regularity of their motion.

**78. Cone Boxes.**

Let  $L_s$  = r.p.m. of rack wheel shaft.

„  $n_s$  = r.p.m. of 1st and main driving shaft in box.

„  $e$  = number of teeth in twist change wheel.

„  $f$  = „ „ large stud wheel.

„  $g$  = „ „ small stud wheel.

„  $h$  = „ „ driven top cone shaft  
wheel.

„  $k$  = diameter in inches of top cone.

„  $l$  = „ „ bottom cone.

„  $m$  = number of teeth in driving bottom cone wheel.

„  $n$  = „ „ driven differential shaft.

„  $o$  = „ „ driving bevel wheel on  
differential shaft.

„  $p$  = „ „ driven bevel wheel on top  
of vertical shaft.

„  $q$  = „ „ driving bevel wheel on  
bottom of vertical  
shaft.

„  $r$  = „ „ striking bevel wheels on  
strike shaft.

„  $s$  = „ „ lifter change wheel.

„  $t$  = „ „ 1st driven large stud  
wheel (broad wheel).

„  $u$  = „ „ 1st driving small stud  
wheel.

„  $v$  = „ „ 2nd driven large stud  
wheel.

„  $w$  = „ „ 2nd driving small stud  
wheel.

„  $x$  = „ „ 2nd driven rack shaft  
wheel.

$$\text{Then } L_r = n_r \left( \frac{e g}{f h} \frac{k}{l} \frac{m}{n} \frac{o}{p} \frac{q}{r} \right) \left( \frac{s}{t} \frac{u}{v} \frac{w}{x} \right). \quad (30)$$

79. Let  $y$  = number of teeth in rack wheel.

„  $z$  = „ rack moved per pick.

„  $p_r$  = pitch of teeth common  $y$  and  $z$ .

„  $L_b$  = inside filling length of bobbin in inches.

$$\text{Then } L_b = z p_r = y p_r. \quad (29_1)$$

$$\text{Let } L_b = 14 \text{ inches.}$$

$$„ \quad y = 20.$$

$$„ \quad p_r = \frac{3}{8} \text{ inch.}$$

$$„ \quad N_r = \text{total revolutions of rack shaft and wheels} \\ x \text{ and } y \text{ to cause lifter to pick distance} \\ L_b.$$

$$N_r = L_b / y p_r = 14 / 20 \times 3/8 = 1.86 \text{ revs.}$$

$$\text{Ans. } (30_1)$$

1 rev. of rack shaft and wheel  $y = y p_r = 20 \times 3/8$   
 $= 7.5$  inches;  $1.86$  revs. of rack shaft and wheel  $y$   
 $= N_r = L_b = 14$  inches.

When the rack shaft has made  $N_r$  revolutions, its action must be reversed. This is the case on all cone boxes, and is accomplished by means of two strike wheels,  $r$  and  $r_1$ , on the striking shaft actuated by the strike shaft from the "Box of Tricks," then one catch is immediately released and the other engaged, one pawl is released and the other engaged, a weight pulls cone rack, and consequently pulls cone belt the distance required for the proper speed of differential shaft, actuating vertical shaft, which transmits its motion to the other strike wheel, which is now engaged. From this point, and at this particular instant, the lifter pick is

reversed, its speed decreased, but the value  $N_r$  remains the same.

80. Now,  $N_r/L_s = t$ , time in minutes to make this particular pick.

Letting subscript numerals 1, 2, 3, etc., equal number of picks respectively.

$$\text{Then } t = \frac{N_r}{L_{s1}} + \frac{N_r}{L_{s2}} + \frac{N_r}{L_{s3}} + \frac{N_r}{L_{s4}} + \dots + \frac{N_r}{L_{s1}} \dots (31)$$

$$\text{And } t = t_1 + t_2 + t_3 + t_4 + \dots + t_1 \dots (32)$$

Where  $t_1$ ,  $t_2$ ,  $t_3$ , and  $t_4$  equals time in minutes taken for each pick,  $L_b$ ,

And  $t$  = total time in minutes taken to fill bobbin.

As the bobbin is filling, the lifter speed decreases, due to cone strap moving along top cone, the diameter decreasing, but the speed remaining constant.

Note  $L_s$  varies as  $e$  directly.

Also  $L_s$  „ „ „ „

∴  $L_s$  „ „ „  $e$   $s$  conjointly.

81. In formula (30), the factors,  $f$ ,  $g$ ,  $h$ ,  $m$ ,  $n$ ,  $o$ ,  $p$ ,  $q$ ,  $r$ ,  $t$ ,  $u$ ,  $v$ ,  $w$ , and  $x$ , whose permanent numerical value may be reduced to a constant factor, which let equal  $C_{L_s}$ .

$$\text{Then } L_s = C_{L_s} n_s e s k/l. \dots (33)$$

Let	$f$	$g$	$h$	$m$	$n$	$o$	$p$	$q$	$r$	$t$	$u$	$v$	$w$	$x$
1. =	50	30	52	20	72	18	52	22	52	35	20	55	26	85
2. =	52	29	55	20	70	23	51	22	52	35	18	58	34	85
3. =			50	22	60	25	50	22	52	35	20	60	32	85

Substituting Column (1) in (30).

$$\text{Then } L_s = n \frac{e}{50} \frac{30}{52} \frac{k}{l} \frac{20}{72} \frac{18}{52} \frac{22}{52} \frac{s}{35} \frac{20}{55} \frac{26}{85}.$$

$$L_s = 1.491 \times 10^{-6} n_s e s k/l.$$

$$\text{And } C_{L_s} = 1.491 \times 10^{-6}.$$

Again (2)

$$L_s = n_s \frac{e}{52} \frac{29}{55} \frac{k}{l} \frac{20}{70} \frac{23}{51} \frac{22}{52} \frac{s}{35} \frac{18}{58} \frac{34}{85}.$$

$$L_s = 1.960 \times 10^{-6} n_s e s k/l.$$

$$\text{And } C_{L_s} = 1.960 \times 10^{-6}.$$

Again (3)

$$L_s = n_s \frac{e}{j} \frac{g}{50} \frac{k}{l} \frac{22}{60} \frac{25}{50} \frac{22}{52} \frac{s}{35} \frac{20}{60} \frac{32}{85}.$$

$$L_s = 5.576 \times 10^{-6} n_s e s k/l.$$

$$\text{And } C_{L_s} = 5.576 \times 10^{-6}.$$

The values of  $k$  and  $l$  can be obtained by using calipers.

**82. Spinning and twisting frame lifter motion speeds** may be studied together owing to their being similar, the double-ended bobbin connecting them with drawing boxes.

Let  $L_p$  = number of lifter picks per minute.

„  $n_c$  = r.p.m. of cylinder.

„  $m$  = diameter in inches of pulley on end of cylinder shaft.

„  $n$  = „ „ driven lifter pulley.

„  $o$  = number of teeth in lifter change wheel.

„  $p$  = „ „ driven stud wheel.

„  $q$  = first kind of worm on other end of stud wheel shaft.

„  $r$  = number of teeth in driven worm wheel on heart-cam shaft, one revolution of which gives two picks of lifter, one up and one down.

Then 
$$L_p = n_c \frac{m}{n} \frac{o}{p} \frac{q}{r} \frac{2}{1} \dots \dots \dots (34)$$

Let  $L_b$  = size of heart-shaped cam.

83. **For spools**, the lifter pick is only a fraction of  $L_b$ , and is started at the bobbin head, which even this fraction of  $L_b$  is reduced to half by the action of the rack, this being moved out of action when the cone is built, the base of which is equal to the outside diameter of bobbin head, the full pick being equal to size of cam used.

Let  $h_p$  = length in inches of pick of heart cam (full).

„  $N_s$  = number of revolutions of scroll screw shaft to move lifter plates the distance  $L_b - h_p$ , the perpendicular filling part of spool,  $H_p$ .

„  $w$  = pitch of scroll shaft screw in inches.

„  $H_p$  = length in inches of perpendicular filling part of spool.

Then 
$$N_s = (L_b - h_p) / w \dots \dots \dots (35)$$

*Example.*—Let  $L_b = 4\frac{1}{4}$  inches,  $h_p = 1\frac{1}{4}$  inches, and  $w = \frac{1}{2}$  inch.

Substituting in (35)

Then  $N_s = (4\frac{1}{4} - 1\frac{1}{4}) / \frac{1}{2} = 6$  revolutions. *Ans.*

The  $N_r$  in (30) and  $N_s$  are analogous; the latter may be considered as one complete pick,  $H_p$ , made up of a certain number of picks,  $h_p$ .

84. Let  $L_s$  = r.p.m. of scroll screw shaft.

„  $s$  = second kind of worm on heart-cam shaft.

„  $t$  = number of teeth on worm wheel on motion shaft.

„  $u$  = „ „ in motion wheel.

„  $v$  = „ „ in scroll wheel.

$$\text{Then } L_s = n_c \left( \frac{m}{n} \frac{o}{p} \frac{q}{r} \right) \left( \frac{s}{t} \frac{u}{v} \right). \quad (36)$$

Let  $t_2$  = time in minutes to perform  $N_s$ .

$$\text{Then } t_2 = N_s/L_s. \quad (37)$$

*Note.*—During the forming of the cone portion of a spool, the scroll screw shaft revolves.

Let  $n_s$  = number of revolutions of scroll screw shaft up to point of *full* pick of heart-cam.

„  $t_1$  = time in minutes to perform  $n_s$ .

$$\text{Then } t_1 = n_s/L_s. \quad (38)$$

Let  $t$  = *total* time in minutes to perform  $N_s$  plus  $n$ .

$$\begin{aligned} \text{Then } t &= t_1 \text{ plus } t_2 = n_s/L_s \text{ plus } N_s/L_s \\ &= (n_s \text{ plus } N_s)/L_s. \end{aligned} \quad (39)$$

*Examples.*

85. (1) A spinning frame has the following dimensions in the lifter train :— $n_c = 600$ ,  $m = 2$ ,  $n = 7\frac{1}{4}$ ,  $p = 100$ ,  $q$  = single,  $r = 62$ . Find  $L_p$ .

Substituting in (34)

$$\text{Then } L_p = 600 \frac{2}{7\frac{1}{4}} \frac{o}{100} \frac{1}{62} \frac{2}{1}.$$

$$L_p = 0.056720o = 5.672 \times 10^{-2}o. \quad \text{Ans.}$$

(2) A spinning frame has the following dimensions in the lifter train :— $n_c = 600$ ,  $m = 5$ ,  $n = 7$ ,  $p = 100$ ,  $q$  = single,  $r = 62$ ,  $s$  = single,  $t = 30$ , and  $v = 40$ . Find  $L_s$ .

Substituting in (36)

$$\text{Then } L_s = 600 \frac{5}{7} \frac{o}{100} \frac{1}{62} \frac{1}{30} \frac{u}{40}.$$

$$L_s = 6.479 \times 10^{-5} o u. \quad \text{Ans.}$$

## CHAPTER VII.

**MACHINES—VELOCITY RATIO OF CARRIER RACE.**

86. ONE who has had any experience in a drawing and spinning room will doubtless have seen a box or frame in motion with the draft race accessories removed, and if one were to place the hand on the moving back roller, commencing with the wrist bearing downwards on the whole race, the effect of the acceleration would be felt, and which it is the purpose of this chapter to state in mathematical language. There is no intention to discuss the merits or demerits of any velocity ratio. The following formulæ, developed for spinning frames, are also sufficient for drawing boxes.

Let  $n_r$  = r.p.m. of B.R.

„  $\alpha$  = number of teeth in driving wheel on B.R.

„  $\beta$  = „ „ follower stud wheel on end of 1st carrier.

„  $\gamma$  = „ „ driving stud wheel on end of 1st carrier.

„  $\delta$  = „ „ driven wheel on end of 2nd carrier.

„  $\varepsilon$  = „ „ driven wheel on end of 3rd carrier.

„  $n_1$  = r.p.m. of 1st carrier.

„  $n_2$  = „ 2nd carrier.



Let  $n_3 =$  r.p.m. of 3rd carrier.

„  $v_r =$  velocity of B.R.

„  $v_1 =$  „ 1st carrier.

„  $v_2 =$  „ 2nd carrier.

„  $v_3 =$  „ 3rd carrier.

„  $d_1 =$  diameter in inches of 1st carrier.

„  $d_2 =$  „ „ 2nd carrier.

„  $d_3 =$  „ „ 3rd carrier.

Then 
$$\begin{array}{cccc} n_r & n_1 & n_2 & n_3 \\ || & || & || & || \\ \text{and} & n_r & n_r \frac{\alpha}{\beta} & n_r \frac{\alpha}{\delta} \end{array}$$

Hence 
$$\begin{array}{cccc} v_r & v_1 & v_2 & v_3 \\ || & || & || & || \\ n_r \pi r, & n_r \frac{\alpha \pi d_1}{\beta}, & n_r \frac{\alpha \pi d_2}{\delta}, & n_r \frac{\alpha \gamma \pi d_3}{\beta \varepsilon}, \end{array}$$

dividing *each* velocity by velocity of B.R.

Then 
$$\begin{array}{cccc} \frac{n_r \pi r}{n_r \pi r}, & \frac{n_r \alpha \pi d_1}{n_r \beta \pi r}, & \frac{n_r \alpha \pi d_2}{n_r \delta \pi r}, & \frac{n_r \alpha \gamma \pi d_3}{n_r \beta \varepsilon \pi r}. \\ || & || & || & \\ 1 & \frac{\alpha d_1}{\beta r}, & \frac{\alpha d_2}{\delta r}, & \frac{\alpha \gamma d_3}{\beta \varepsilon r}. \end{array} \quad (40)$$

87. *Examples.*—The values given below are the dimensions for carrier race trains on spinning frames :—

	$\alpha$	$\beta$	$\gamma$	$\delta$	$\varepsilon$	$r$	$d_1$	$d_2$	$d_3$
(1)	34	23	21	21	17	$1\frac{1}{4}$	$\frac{29}{32}$	$\frac{29}{32}$	$\frac{3}{4}$
(2)	34	23	21	21	19	$1\frac{1}{4}$	$\frac{29}{32}$	$\frac{29}{32}$	$\frac{29}{32}$
(3)	34	19	18	18	17	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$

Then velocity ratios are by substituting in (40),

	B.R	1st Carrier.			2nd.			3rd.			
(1)	1	$\frac{34}{23}$	$\frac{29}{32}$	$\frac{4}{5}$	$\frac{34}{21}$	$\frac{29}{32}$	$\frac{4}{5}$	$\frac{34}{23}$	$\frac{21}{17}$	$\frac{3}{4}$	$\frac{4}{5}$
	1	1·0717 ;			1·1738 ;			1·2000.			
(2)	1	$\frac{34}{23}$	$\frac{29}{32}$	$\frac{4}{5}$	$\frac{34}{21}$	$\frac{29}{32}$	$\frac{4}{5}$	$\frac{34}{23}$	$\frac{21}{19}$	$\frac{29}{32}$	$\frac{4}{5}$
	1	1·0717 ;			1·1738 ;			1·2974.			
(3)	1	$\frac{34}{19}$	$\frac{7}{8}$	$\frac{2}{3}$	$\frac{34}{18}$	$\frac{7}{8}$	$\frac{2}{3}$	$\frac{34}{19}$	$\frac{18}{18}$	$\frac{7}{8}$	$\frac{2}{3}$
	1	1·0439 ;			1·1018 ;			1·1667.			

## CHAPTER VIII.

## W O O L.

88. **Fundamental and Derived Units.**—The units of **time**, **length**, and **mass** are termed “fundamental units,” as upon them all other units depend. These three units *need* have no connection with one another—*e.g.*, the selection of a certain length for a unit of length is in no way limited by the choice of a unit of mass or a unit of time. All other units to be dealt with are dependent upon the three fundamental units, and cannot be chosen arbitrarily; they are in consequent called “derived units.”

89. **Two Systems of Units.**—As a result of the freedom on choice in the selection of the fundamental units, the systems of all nations are not the same. Having to deal with two systems in the work, the English and Metric, care must be taken to keep these quite distinct, and these will only be dealt with for the purpose of counting or comparing yarns and slivers.

90. **The English worsted count** indicates the number of hanks required to weigh one pound avoirdupois, and, therefore, the unit of length is one hank (560 yards) and the unit of weight is 1 lb. (av.).

Then  $560 \text{ yds.} = 1 \text{ hank} = 1 \text{ lb.} = 1\text{'s counts.}$

$2 \times 560 \text{ „} = 2 \text{ hanks} = 1 \text{ lb.} = 2\text{'s „}$

$3 \times 560 \text{ „} = 3 \text{ „} = 1 \text{ lb.} = 3\text{'s „}$

$50 \times 560 \text{ „} = 50 \text{ „} = 1 \text{ lb.} = 50\text{'s „}$

$C_e \times 560 \text{ „} = C_e \text{ „} = 1 \text{ lb.} = C_e\text{'s „}$

**Letting**  $C_e = \text{English count.}$

Now 1 lb. = 16 ozs. = 256 drms. = 7,000 grains (grs.).

But  $1 \times 560$  yds. = 1 hank = 7,000 grs.

Hence 1 yd. of 1's count =  $12\frac{1}{2}$  „

„ 2 yds. of 2's count =  $12\frac{1}{2}$  „

„ 3 yds. of 3's count =  $12\frac{1}{2}$  „

„ 50 yds. of 50's count =  $12\frac{1}{2}$  „

∴  $C_c$  yds. of  $C_c$  counts =  $12\frac{1}{2}$  „

### 91. Avoirdupois Weight.

1 dram = 27.34375 grains.

16 drams = 1 oz. = 437.5 grains.

16 ozs. = 1 lb. = 7,000 „

*Abbreviations.*—

dr. dram ; gr. grain ; gm. gramme.

*Safe Weight.*—The  $12\frac{1}{2}$  gr. weight is used as a *safe* weight. The length in yards is measured usually on a hexagonal reel, the length of the side being 6 inches ; consequently,  $6 \times 6 = 36$  inches = 1 yard.

92. The **Metric worsted count** indicates the number of kilometres (km.) required to weigh 1 kilogramme (kg.), and, therefore, the unit of length is 1 km., the length of 1,000 metres and the unit of weight is 1 kg.

Then 1,000 metres = 1 km. = 1 kg. = 1's counts.

$2 \times 1,000$  „ = 2 km. = 1 kg. = 2's „

$3 \times 1,000$  „ = 3 km. = 1 kg. = 3's „

$50 \times 1,000$  „ = 50 km. = 1 kg. = 50's „

$C_m \times 1,000$  „ =  $C_m$  km. = 1 kg. =  $C_m$ 's „

**Letting**  $C_m$  = metric count.

But	$1 \times 1,000$ metres	$= 1$ km.	$= 1,000$ grs.
	1 metre of 1's count	$= 1$ grm.	
	2 metres of 2's count	$= 1$ „	
	3 „ 3's count	$= 1$ „	
	50 „ 50's count	$= 1$ „	
	$C_m$ „ $C_m$ 's count	$= 1$ „	

*Note.*—The two systems may be named as follows :—

The *English* or hank-pound system,  
or yard,  $12\frac{1}{2}$  grain system.

The *Metric* or kilometre, kilogramme system,  
or metre-gram system.

**93. The Connecting Link** between the hank-pound (H.P.) and kilometre-kilogram (K.m.g.) systems :—

#### LENGTH.

1 inch	$= 2.54$ cm.	1 cm.	$= 0.39370113$ in.
1 foot	$= 30.4799$ cm.	1 m.	$= 39.370113$ ins.
1 yard	$= 0.914399$ m.	1 m.	$= 3.280843$ ft.
1 mile	$= 5,280$ feet.	1 m.	$= 1.0936143$ yds.
1 mile	$= 1.6093$ km.	1 km.	$= 0.62137$ ml.

#### MASS.

1 grain	$= 0.0648$ grm.	1 gram	$= 0.0022046$ lb.
1 dram	$= 1.772$ grms.	1 „	$= 15.432$ grs.
1 oz. (av.)	$= 437.5$ grs.	1 kilo	$= 2.2046$ lbs.
1 „	$= 28.350$ grms.		
1 lb. (av.)	$= 16$ ozs.		
1 „	$= 7,000$ grs.		
1 „	$= 543.5924$ grms.		

## CHANGE OF UNITS.

94. Now one hank equals 1 lb. equals 1 count (Eng.).

And 1 km. = 1 kg. = 1 count (M.)

1,093·6 yds. = 2·2046 lbs. = 1 count (M.)

496 yds. of  $C_m$ 's = 1 lb.

But 560 yds. of  $C_e$ 's = 1 „

Hence 560  $C_e$  = 496  $C_m$ .

$$C_e = \frac{496}{560} C_m = 0·8857 C_m. \quad (41)$$

$$C_m = \frac{560}{496} C_e = 1·129 C_e. \quad (42)$$

*Note.*—512 metres = 560 yards = 1 hank ; also 560  $\pi$  = 1 mile.

95. The wool as received in the drawing room is in the form of tops. The trade make these to a supposed standard—viz., 4 to 10 ozs. per 10 yards. The one in charge in drawing does not use this standard ; in fact, few know of it, except students who pass through the technical schools. It is customary to measure off a length of 4 to 8 yards, and to weigh this and express the weight in drams. Even this is not always done ; frequently the tops of sliver are placed in the creel of 1st can gill box, with as many ends up as the creel will allow. This passes through the spindle gill box and drawing box to the weigh box (W.B.), where it is now adjusted to the desired weight necessary for its reduction with the doublings and drafts to produce the weight of roving required. In considering the total reduction in the sliver from tops to yarns, it becomes necessary to change the units of weight and length, and much is

done in the English system that is never realised by the practical man. In the first place, due to the separation in drawing and spinning, the drawing man only thinks of a certain weight of roving, and this to be brought about by placing and running through a drawing—not of his own choosing, but simply because it is running out—the management sends the tops to him, when, many times, quite unnecessary changes are made, together with an unsuitable set of drawing machinery.

Again, as the roving is expressed per 40 or 80 or 120 yards, and the yarn is expressed in counts, the connecting link between these is seldom fully grasped. The spinning man, due to the *practice* in the mills, the *application only of rules* in the technical schools, and the *expression of English weights and measures*, finds that all these factors combined are responsible for the bad state of affairs.

96. A spinner receives an order for 60's, both two-fold and single yarns. Due to custom and practice built up in days gone by, a so-called 60's top is brought for this purpose and put into a drawing with 10 sets of machines or operations, from and through which a roving is produced of 3 drms. of 80 yds. with a draft of 5 in the spinning. Now, in the trade, this would be as follows :—

Weight of top sliver, . 4 ozs. per 10 yds.

„ roving sliver, 3 drms. per 80 yds.

And counts, . . . 1 lb. per  $60 \times 560$  yds.

12½ grs. per 60 yds.

Now, to *know* the total reduction in the sliver from top to yarn is to bring each of the above factors given to a common denominator. The trade simply use *various weights in drms. within limits* for 1/14, 1/7, and 3/14 of

a hank which is 40, 80, and 120 yds. respectively. This is followed, lastly, by the weight of 1 lb. (av.) for counts the multiple of the number of hanks.

$$\begin{aligned}\text{Let } w &= \text{weight in drms. of a length } l \text{ yds.} \\ \text{,, } W &= \text{,, lbs.} \quad \text{,, } L \text{ yds.} \\ \text{,, } H &= \text{number of hanks per lb. (or counts).} \\ \text{,, } l &= \text{,, yds. per } w \text{ drms.} \\ \text{,, } L &= \text{,, yds. per 1 lb.}\end{aligned}$$

Then  $560 H \text{ yds.} = 1 \text{ lb.} = 256 \text{ drms.}$

and  $1 \text{ yd.} = w \text{ drms.}$

$$\text{Then } \frac{560}{256} H = \frac{l}{w}.$$

$$\therefore H = \frac{256}{560} \frac{l}{w}. \quad . \quad . \quad . \quad . \quad . \quad (43)$$

$$\therefore H = 0.4571 \frac{l}{w}. \quad . \quad . \quad . \quad . \quad . \quad (44)$$

97. Now (43) and (44) are conversion formulæ for finding the *count* of sliver when its weight in drams and length in yards are given and known. At this point, it would be advisable to find those three well-known numbers or "gauge points" for 40, 80, and 120 yds. of roving.

$$\text{Then } H = \frac{256}{560} \frac{l}{w} = \frac{256}{560} \frac{40}{w} = \frac{18.3}{w}. \quad . \quad . \quad . \quad . \quad (43_1)$$

$$\text{,, } H = \frac{256}{560} \frac{l}{w} = \frac{256}{560} \frac{80}{w} = \frac{36.6}{w}. \quad . \quad . \quad . \quad . \quad (43_2)$$

$$\text{,, } H = \frac{256}{560} \frac{l}{w} = \frac{256}{560} \frac{120}{w} = \frac{54.9}{w}. \quad . \quad . \quad . \quad . \quad (43_3)$$

Now,  $p$  = this constant 18.3, 36.6, or 54.9, as the case may be.

$$\text{Then } H w = p. \quad . \quad . \quad . \quad . \quad . \quad (45)$$



98. It becomes necessary to particularise  $H$ .

Let  $H_r$  = hanks per lb. of roving or count.

If, now, this  $H_r$  be drawn out in spinning to  $H_y$ , and let  $H_y$  = hanks per lb. of yarn or count, and  $d$  = draft,

$$\begin{aligned} \text{Then} \quad H_r d &= H_y. \\ \therefore d &= H_y / H_r. \end{aligned} \quad (46)$$

$$\therefore d = H_y \cdot \frac{256}{560} \cdot \frac{l}{w}.$$

$$\therefore d = H_y \cdot \frac{p}{w}.$$

$$\therefore d = H_y \cdot w/p. \quad (47)$$

99. Every firm which expresses its rovings in drams per fraction of a hank makes it necessary for those in charge of spinning to find the draft by multiplying the counts or hanks per pound of yarn by the weight in drams of roving to be used, and dividing this by the gauge point of the standard number of yards of roving used, gives the draft required. The above rule is used daily, but the derivation of this formula (47) is little understood. To those who express their rovings in counts, it becomes necessary to use formula (46). The writer has found but one firm which adopts the latter method, although literature on the subject seems to point that the calculation may be made mentally. To this the writer agrees, as, for instance, by (46) :—

$$d = \frac{H_y}{H_r} = \frac{60's}{6's} = \frac{40's}{4's} = \frac{20's}{2's} = 10. \quad Ans.$$

This would be quite simple, *if* the counts of rovings and yarns *were* actual, but in practice they are not, and consequently defeat their objective. To those who

can use a watch calculator or modern slide rule with sliding cursor, formula (47) would suggest itself. Whether one uses formula (46) or (47) in order to find the value of  $d$ , unless this be carried to the second decimal point, by dividing into the gauge point, for draft, the correct wheel would not be ascertained. Instead of using two formulæ, one formula can be derived which will give the draft wheel direct.

Derivation of formula for draft wheel :—

Now, Section 29 gives  $d = \frac{P}{A}$  generally. . . . . (2)

And by (47)  $d = H_y w/p$ . . . . . (47)

Hence  $\frac{H_y w}{p} = \frac{P}{A}$ .

By transposing,

Then  $A = \frac{P p}{H_y w}$ . . . . . (48)

This formula gives value of  $A$  direct. Notice the two gauge points are above the line as numerators, and consequently  $H_y$  and  $w$ , the only other two factors, must come below the line as denominators.

100. **A Practical Case.**—A mill manager, with many years' experience, after several attempts to find the counts of roving as a sample for the office, brought to the writer a  $5 \times 3$  roving bobbin with a few yards of roving round the barrel to ascertain the counts. By placing the bobbin on one of the reel pegs one was able to reel off 13 yds., and found it to weigh 1·3 drams. By using formula (43),

$$H = \frac{256}{560} \frac{l}{w}$$

and substituting,

$$H = \frac{256}{560} \cdot \frac{13}{1.3} = 4.57. \quad \text{Ans.}$$

The counts were, therefore,  $4\frac{1}{2}$ 's.

101. *Example.*—It is required to spin  $2/36$ 's from a 3-dram roving for 40 yds., to be spun 5 per cent. light. Now, 5 per cent. of 36's = 1.8.  $H_y = 37.8$ . The 3-dram roving weighed 3.15 drams.

The gauge point (P) for spinning frame draft race was 381.

$$\text{By (48)} \quad A = \frac{P \cdot p}{H_y \cdot w}.$$

$$\therefore \quad A = \frac{381 \times 18.3}{37.8 \times 3.15}.$$

$$\therefore \quad A = 59 \text{ teeth in draft wheel.} \quad \text{Ans.}$$

102. In Section 94 the relationship between the English and Metric count was presented.

Below is given an alternative method:—

Let  $H_e$  = English count.

„  $H_m$  = Metric count.

Then  $H_e$  560 yds. = 1 lb.

$$H_e \text{ 560} \times 0.914399 = 453.5924 \text{ grms.}$$

$$H_e \frac{560 \times 0.914399}{453.5924} = 1 \text{ gm.}$$

$$H_e \text{ 1.129} = \text{metres per gm.} \quad . \quad . \quad (49)$$

Now, formula (43),

$$H_e = \frac{256}{560} \cdot \frac{l}{w} = 36.57/w.$$

And (42) gives

$$H_m = \frac{560}{496} H_e.$$

$$H_m = \frac{560}{496} \frac{256}{560} \frac{l}{w}.$$

$$H_m = \frac{256}{496} \frac{l}{w} \quad . \quad . \quad . \quad . \quad . \quad . \quad (50)$$

$$H_m = 0.5161 \, l/w. \quad . \quad . \quad . \quad . \quad . \quad (51)$$

When  $l = 80$  yds.

$$\text{Then } H_m = 41.29/w. \quad . \quad . \quad . \quad . \quad . \quad (52)$$

*Note.*—The Metric count is number of kilometres per  
kilogramme.

or                    "                    "                    "                    metres per  
gramme.

English count is number of hanks per lb.

or                    "                    "                    "                    yards per  
12½ grains.

103. The top sliver is made to standard sizes of 4 to 10 ozs. for 10 yds. The writer invariably uses the length of 80 yds. in practice, and will do so here, the reason being apparent later.

The table on p. 76 is given for technical students; those in actual practice would weigh a length of 8 yds. in drams, multiplying by 10, would give weight for 80 yds., and by using formula (43) would obtain the count.

Until some decimal system—not necessarily the Metric system—becomes compulsory in the trade, the slivers in the drawing room will remain to be expressed in drams and yards. Owing to the management placing

TABLE XIII.

Oz.	$w$ for $l=1,000H_m$ or $10^3H_m=1,000H$ , or $10^3H_e$		
4 in 10 yds. =	512 for 80 = 80.63 m. per kg.	= 71.42 mh. per lb.	
5 in 10 yds. =	640 for 80 = 64.51	„ = 57.14	„
6 in 10 yds. =	768 for 80 = 53.75	„ = 47.61	„
7 in 10 yds. =	896 for 80 = 46.08	„ = 40.82	„
8 in 10 yds. =	1,024 for 80 = 40.28	„ = 35.72	„
9 in 10 yds. =	1,152 for 80 = 35.83	„ = 31.74	„
10 in 10 yds. =	1,280 for 80 = 32.25	„ = 28.57	„

Note.—mh. = millihanks per lb.

persons in charge of sets of drawing machinery, which they expect to be utilised to the utmost capacity for the reduction of top sliver into roving, one is compelled to work within the limits of custom. As a Botany set of drawing machinery contains the maximum number of operations, the following formulæ will be comprehensive:—

104. Let  $w_l$  = weight in drams of  $l$  yds. of top sliver as received.

„  $w$  with subscript numerals 1, 2, 3, 4, 5, 6, 7, 8, and 9 = respectively weights in drams of sliver paid out by F.R. of boxes in each operation.

„  $e$  = number of ends compounded and put in B.R. (doublings).

„  $d$  = equal draft in drawing for each operation.

„  $d$  with subscript numerals 1, 2, 3, 4, 5, 6, 7, 8, and 9 = drafts in the several operations.

**C.G., S.G., D.B., W.B., 1.F., 2.F., 1.R., 2.R., r.**

$$\text{Then } w_t \frac{e_1}{d_1} \frac{e_2}{d_2} \frac{e_3}{d_3} \frac{e_4}{d_4} \frac{e_5}{d_5} \frac{e_6}{d_6} \frac{e_7}{d_7} \frac{e_8}{d_8} \frac{e_9}{d_9} = w. \quad (53)$$

$$,, \quad w_t \frac{e_1}{d} \frac{e_2}{d} \frac{e_3}{d} \frac{e_4}{d} \frac{e_5}{d} \frac{e_6}{d} \frac{e_7}{d} \frac{e_8}{d} \frac{e_9}{d} = w. \quad (54)$$

Now,  $w_t$  (the weight of top sliver) and  $w$  (the weight of roving) are known. Also, the doublings are determined—in practice at least—by the size of creel in each machine, and these may be used to the extreme limits, as previously explained, the value of  $e$  consequently being known.

The least value of draft,  $d$ , is an equal draft, which, of course, is preferable, and the only way of making a calculation. An equal draft has never been attained in practice, and it, therefore, remains for the value of  $d$  to be found.

Transposing in (54),

$$\text{Then } w d^9 = w_t e_1 e_2 e_3 e_4 e_5 e_6 e_7 e_8 e_9.$$

$$\therefore d^9 = w_t e_1 e_2 e_3 e_4 e_5 e_6 e_7 e_8 e_9 / w.$$

$$\text{And } \log d = \frac{1}{9} \left\{ \begin{array}{l} \log w_t + \log e_1 + \log e_2 + \log e_3 \\ + \log e_4 + \log e_5 + \log e_6 + \log e_7 \\ + \log e_8 + \log e_9 - \log w. \end{array} \right. \quad (55)$$

105. Having now found the value of  $d$ , it becomes necessary to find the weight,  $w$  (in drams), of sliver paid out by F.R. in each box or machine—

Hence,  $w_t e_1 / d = w_1$  for front of C.G.B.

$$\text{And } w_1 e_2 / d = w_2 \quad ,, \quad \text{S.G.B.}$$

$$,, \quad w_2 e_3 / d = w_3 \quad ,, \quad \text{D.B.}$$

$$,, \quad w_3 e_4 / d = w_4 \quad ,, \quad \text{W.B.}$$

$$,, \quad w_4 e_5 / d = w_5 \quad ,, \quad 1 \text{ F.B.}$$

$$,, \quad w_5 e_6 / d = w_6 \quad ,, \quad 2 \text{ F.B.}$$

$$,, \quad w_6 e_7 / d = w_7 \quad ,, \quad 1 \text{ R.B.}$$

$$,, \quad w_7 e_8 / d = w_8 \quad ,, \quad 2 \text{ R.B.}$$

$$,, \quad w_8 e_9 / d = w_9 \quad ,, \quad \text{r.B.}$$

## EXAMPLE.

Tops are received to produce a 9-dram per 80 yds. of roving. The weight of top sliver is found to be 450 drams per 80 yds.

*Note.*—These tops are lighter than the supposed standard, the firm in question producing its own tops. The doublings or ends up are as follows:—

$e_1 = 6, e_2 = 3, e_3 = 4, e_4 = 4, e_5 = 3, e_6 = 3, e_7 = 3, e_8 = 3,$   
and  $e_9 = 2$ .

Then  $\frac{w_1 e_1}{d_1} \frac{e_2}{d_2} \frac{e_3}{d_3} \frac{e_4}{d_4} \frac{e_5}{d_5} \frac{e_6}{d_6} \frac{e_7}{d_7} \frac{e_8}{d_8} \frac{e_9}{d_9} = w.$

$$,, \quad \frac{450 \times 6}{d} \frac{3}{d} \frac{4}{d} \frac{4}{d} \frac{3}{d} \frac{3}{d} \frac{3}{d} \frac{3}{d} \frac{2}{d} = 9.$$

$$,, \quad \left. \begin{array}{l} d^9 = 450 \times 72^2 \\ \log d = \frac{1}{9} (\log 450 + 2 \log 72) \end{array} \right\} \begin{array}{l} \log 450 = 2.6532 \\ 2 \log 72 = 3.7146 \end{array}$$

$$\therefore d = 5.1. \quad \text{Ans.} \quad \underline{\underline{9)6.3678}}$$

$$\underline{\underline{5.1 = 0.7075}}$$

$$106. \text{ Now } \frac{w_1 e_1}{d_1} = \frac{450 \times 6}{5.1} = 530 = w_1 \text{ front of C.G.B.}$$

$$\text{And } \frac{w_1 e_2}{d_2} = \frac{530 \times 3}{5.1} = 312 = w_2 \quad ,, \quad \text{S.G.B.}$$

$$,, \quad \frac{w_2 e_3}{d_3} = \frac{312 \times 4}{5.1} = 245 = w_3 \quad ,, \quad \text{D.B.}$$

$$,, \quad \frac{w_3 e_4}{d_4} = \frac{245 \times 4}{5.1} = 192 = w_4 \quad ,, \quad \text{W.B.}$$

$$,, \quad \frac{w_4 e_5}{d_5} = \frac{192 \times 3}{5.1} = 113 = w_5 \quad ,, \quad \text{I.F.B.}$$

$$\begin{aligned}
 \text{And} \quad \frac{w_5 e_6}{d_6} &= \frac{113 \times 3}{5 \cdot 1} = 66 \cdot 5 = w_6 \text{ front of 2 F.B.} \\
 \text{,,} \quad \frac{w_6 e_7}{d_7} &= \frac{66 \cdot 5 \times 3}{5 \cdot 1} = 39 = w_7 \quad \text{,,} \quad 1 \text{ R.B.} \\
 \text{,,} \quad \frac{w_7 e_8}{d_8} &= \frac{39 \times 3}{5 \cdot 1} = 23 = w_8 \quad \text{,,} \quad 2 \text{ R.B.} \\
 \text{,,} \quad \frac{w_8 e_9}{d_9} &= \frac{23 \times 2}{5 \cdot 1} = 9 = w_9 \quad \text{,,} \quad r.\text{B.}
 \end{aligned}$$

107. A 9-dram roving would be 4's counts, and a 6-dram roving would be 6's counts, and taking a maximum draft of 6, they would spin to 24's and 36's respectively with the ordinary percentage light for moisture.

By placing the various weights calculated in the example shown, and substituting in Formulæ (43) and (50), the following table is produced :—

TABLE XIV.

Column 1.	Column 2.	Column 3.	Column 4.
$w$	$l$	$(C_m \text{ or } H_m) 10^3.$	$(C_e \text{ or } H_e) 10^3.$
450 dms. per 80 yds. =		91·75 m. per kg. =	81·27 mh. per lb.
530	80 „ =	77·89 „ =	69·00 „
312	80 „ =	132·30 „ =	117·10 „
245	80 „ =	168·50 „ =	149·20 „
192	80 „ =	215·00 „ =	190·40 „
113	80 „ =	365·40 „ =	323·60 „
66·5	80 „ =	620·90 „ =	549·90 „
39	80 „ =	1,059·00 „ =	937·60 „
23	80 „ =	1,795·00 „ =	1,590·00 „
9	80 „ =	4,587·00 „ =	4,063·00 „

$$\text{Total reduction} = \frac{450}{9} = \frac{4,589 \cdot 00}{91 \cdot 75} = \frac{4,063 \cdot 00}{81 \cdot 27} = 50. \text{ Ans.}$$



108. *Note*.—The reduction in the first box is negative, the sliver being heavier in the second box or operation. In Column 4 the millihank per lb. is entirely new and corresponds very closely with Column 3 (the metre-kilogramme). The millihank is given as an engine for further thought and shows equally as well as the metre-kilogramme, the size of sliver in every box of the drawing process in figures of the same denominator. The writer would suggest that all spring balances used in the drawing and spinning rooms should have the sectors for each lb. divided into tenths and these subdivided again, irrespective of what has been said above.

109. Having now derived formulæ for counts—weight and length—from top sliver to roving, it now remains for the consideration of twist, which is turns per 1 inch or revolutions of spindles or tubes during the time it takes the F.R. to deliver 1 inch of sliver. In the drawing very little need be said, only the less twist the sliver will bear for handling purposes from one box or operation to another, the better. Of course, the amount of twist in the roving could be adjusted to give the best spin by arrangement with the spinning. Calculations are not much use, only the underlying principles should be understood.

110. When a sliver reaches the spinning or yarn stage, it has reached its *final* form as a single yarn or count (length or weight).

**The twisting** is for the purpose of compounding these separate yarns for special purposes as the trade demands. The following table will show a series of compounded threads :—

TABLE XV.

$$2/100's = 100/2 = 50 = 1/50's \text{ count.}$$

$$3/60's = 60/3 = 20 = 1/20's \quad ,,$$

$$4/40's = 40/4 = 10 = 1/10's \quad ,,$$

$$5/40's = 40/5 = 8 = 1/8's \quad ,,$$

$$7/7's = 7/7 = 1 = 1/1's \quad ,,$$

$$n/C's = C/n = C/n = 1/C/n's \quad ,,$$

C = counts of yarn to be folded.

And  $n$  = number of threads in folded yarn.

Let  $C_r$  = resultant count.

Then  $C/n = C_r$  . . . . . (56)

$\therefore C = nC_r$  . . . . . (57)

111. In extending the theory of compounding threads where a number of unequal counts have to be folded the problem becomes more intricate. The derivation of a comprehensive formula will doubtless be worthy of an effort to do so. For the sake of simplicity and ease and because the small letters in the alphabet have only been used for machine formulæ, there seems to be no reason why they should not be used here without causing confusion.

Let  $a, b, c, d, e, \dots$ ; represent the *unequal* counts to be compounded and let  $r$  = the resultant count therefrom.

Count $a$	$560 \ a \text{ yds.} = 1 \text{ lb.}$
$,, \ b$	$560 \ b \text{ yds.} = 1 \text{ lb.}$
$,, \ c$	$560 \ c \text{ yds.} = 1 \text{ lb.}$
$,, \ d$	$560 \ d \text{ yds.} = 1 \text{ lb.}$
$,, \ e$	$560 \ e \text{ yds.} = 1 \text{ lb.}$

to

$$\text{Count } l \quad \underline{560 \text{ } l \text{ yds.} = 1 \text{ lb.}}$$

$$,, \quad r \quad \underline{\underline{560 \text{ } r \text{ yds.} = \Sigma W.}}; :: ::$$

$$560 \text{ } a \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } a \text{ lb.}$$

$$560 \text{ } b \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } b \text{ lb.}$$

$$560 \text{ } c \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } c \text{ lb.}$$

$$560 \text{ } d \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } d \text{ lb.}$$

$$560 \text{ } e \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } e \text{ lb.}$$

to

$$560 \text{ } l \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } l \text{ lb.}$$

$$560 \text{ } r \text{ yds.} = 1 \text{ lb.} \quad \therefore 1 \text{ yd.} = 1/560 \text{ } r \text{ lb.}$$

$$560 \text{ } l \text{ yds.} = 560 \text{ } l/560 \text{ } a \text{ lbs.}$$

$$560 \text{ } l \text{ yds.} = 560 \text{ } l/560 \text{ } b \text{ lbs.}$$

$$560 \text{ } l \text{ yds.} = 560 \text{ } l/560 \text{ } c \text{ lbs.}$$

$$560 \text{ } l \text{ yds.} = 560 \text{ } l/560 \text{ } d \text{ lbs.}$$

$$560 \text{ } l \text{ yds.} = 560 \text{ } l/560 \text{ } e \text{ lbs.}$$

to

$$560 \text{ } l \text{ yds.} = 560 \text{ } l/560 \text{ } l \text{ lbs.}$$

$$\text{Hence } 560 \text{ } l \text{ yds.} = \left( \frac{l}{a} + \frac{l}{b} + \frac{l}{c} + \frac{l}{d} + \frac{l}{e} + \dots + \frac{l}{l} \right) \text{ lbs.}$$

By transposition

$$\text{Then} \quad 1 \text{ lb.} = \frac{560 \text{ } l}{\left( \frac{l}{a} + \frac{l}{b} + \frac{l}{c} + \frac{l}{d} + \frac{l}{e} + \dots + \frac{l}{l} \right)} \text{ yds.}$$

$$\text{But} \quad 1 \text{ lb.} = 560 \text{ } r \text{ yds.}$$

$$\text{Then} \quad 560 \text{ } r = \frac{560 \text{ } l}{\left( \frac{l}{a} + \frac{l}{b} + \frac{l}{c} + \frac{l}{d} + \frac{l}{e} + \dots + \frac{l}{l} \right)};$$

$$\therefore \quad r = \frac{1}{\left( \frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d} + \frac{1}{e} + \dots + \frac{1}{l} \right)}. \quad (58)$$

112. *Example*.—It is required to fold 60's, 30's, 20's, and 15's together. Find the resultant.

By using in (58), the number of literal factors required,

$$\text{Then} \quad r = \frac{l}{\left(\frac{l}{a} + \frac{l}{b} + \frac{l}{c} + \frac{l}{l}\right)},$$

$$\text{Whence} \quad r = \frac{60}{\left(\frac{60}{15} + \frac{60}{20} + \frac{60}{30} + \frac{60}{60}\right)}.$$

$$\text{Then} \quad r = \frac{60}{(4 + 3 + 2 + 1)};$$

$$\therefore \quad r = \frac{60}{10} = 6's. \quad \text{Ans.}$$

*Note*.—The calculation is simplified by letting  $a$ , equal lowest, and  $l$ , highest, counts respectively.

113. In practice generally *two* counts are folded, and for this reason a special formula will be derived.

Let the two counts be  $a$  and  $b$  respectively, and let  $r$  equal their resultant.

Substituting in (58) for two counts only,

$$\begin{aligned} \text{Then} \quad r &= \frac{b}{\frac{b}{a} + \frac{b}{b}} = \frac{b}{\frac{b^2 + a b}{a b}}, \\ r &= \frac{a b^2}{b(a + b)} = \frac{a b}{(a + b)}, \\ r &= \frac{a b}{a + b} \quad . \quad . \quad . \quad . \quad . \quad . \quad (59) \end{aligned}$$

114. *Example*.—Find the resultant count when 60's and 40's are twisted together.

Let  $a = 40's$ ;  $b = 60's$ ; and  $r = \text{resultant}$ .

Then substituting in (59),

$$r = \frac{a b}{a + b} = \frac{40 \times 60}{40 + 60} = \frac{40 \times 60}{100} = 24's,$$

$r = 24's$ , the resultant count required.

115. To find a formula for a component count when the other is known together with the resultant.

By (59) 
$$r = \frac{a b}{a + b}$$

whence

$$a r + b r - a b = 0,$$

$$a r - a b = -b r,$$

$$a(r - b) = -b r,$$

$$\therefore a = \frac{-b r}{(r - b)} \quad \dots \quad (60)$$

Again

$$a r + b r - a b = 0,$$

$$b r - a b = -a r,$$

$$b(r - a) = -a r,$$

$$\therefore b = \frac{-a r}{(r - a)} \quad \dots \quad (61)$$

In (60) and (61)  $r < a$  and  $b$   $\therefore (r - a$  or  $b)$  is always negative, hence

$$b = \frac{(-1)}{(-1)} \times \frac{(-a r)}{(r - a)} = \frac{a r}{(-r + a)},$$

$$b = \frac{a r}{(a - r)} \text{ and } a = \frac{b r}{(b - r)} \quad \dots \quad (62) \text{ and } (63)$$

116. *Example.*—The resultant count and one component are 24's and 60's. Find the other component. Then  $r = 24's$ ; and  $b = 60's$ .

Hence by (63)

$$a = \frac{b r}{b - r} = \frac{60 \times 24}{60 - 24} = \frac{60 \times 24}{36} = 40's, \left\{ \begin{array}{l} \text{the other} \\ \text{component.} \end{array} \right.$$

Again, find  $b$  when  $a = 40's$  and  $r = 24's$ .

$$\text{By (62) } b = \frac{a r}{a - r} = \frac{40 \times 24}{40 - 24} = \frac{40 \times 24}{16} = 60's. \quad \text{Ans.}$$

117. Orders are received, at times, for a certain weight of twisted thread to be produced out of two unequal counts. Let the unequal counts be  $a$  and  $b$  respectively, and let  $W_a$  and  $W_b$  be the weights of each required to produce  $W_r$  lbs. of the resultant.

$$\text{Now by (59) } r = \frac{a b}{a + b}.$$

The resultant count  $r's = W_r$  lbs. of folded yarn.

$$\therefore l's = W_r r,$$

$$\therefore a's = W_r r/a. \quad . \quad . \quad . \quad . \quad (64)$$

$$\text{Similarly, } b's = W_r r/b. \quad . \quad . \quad . \quad . \quad (65)$$

$$\text{But } W_r = W_a + W_b. \quad . \quad . \quad . \quad . \quad (66)$$

$$\text{Hence } W_a = \frac{W_r r}{a} \text{ lbs.}$$

$$\text{And } W_b = \frac{W_r r}{b} \text{ lbs.}$$

118. It is required to produce 60 lbs. twist composed of 60's and 40's. The value  $r$  has already been found to be 24's.

$$\text{By (64) } a = \frac{W_r r}{a} = \frac{60 \times 24}{40} = 36 \text{ lbs.}$$

$$\text{By (65) } b = \frac{W_r r}{b} = \frac{60 \times 24}{60} = 25 \text{ lbs.}$$

$$\text{By (66) } W_r = W_a + W_b = 36 + 24 = 60 \text{ lbs.} \quad \text{Ans.}$$

119. **Wool Staple.**—When one in charge of the drawing department receives the top sliver for reducing into

roving, he usually takes hold of the top with one hand, and by nipping the ends of the sliver with the other, pulls out gently a number of fibres. Repeating the operation, he secures a bunch of fibres, the head of which is between the nip of first finger and thumb, these being practically parallel and their length varying according to the quality of the wool.

By placing them on a flat rough showing surface (a piece of velvet secured on a board is recommended), on examination one finds the length of the longest fibres, and judges the proportion of these to the short ones.

**120. Ratch and Ratching.**—For a long wool of 9-inch staple to be run in the drawing, one would set the back roller of the gill-boxes in order that 9 inches from its nip may extend two-thirds or three-quarters over the fallers. (In Botany, the B.R. would be set as near as possible to fallers). In the drawing boxes a little over 9 inches (the amount in excess depending upon the twist in sliver, this also influencing the setting of the carriers) would be advisable; however, practical experience would soon put matters right. Due to force of circumstances, the author in spinning some 9-inch khaki in 1914 made some 24's with the ratch set at  $6\frac{1}{2}$  inches. No trouble was experienced with "nicked" rollers or uneven yarn. This is given for what it may be worth. However, it has not been found advisable for any ratch to be set less than the longest fibres under the present design of machinery and insertion of twist.

## CHAPTER IX.

### MACHINES AND WOOL.

**121. Rate of Production.**—In the introduction,\* a *rate* of drafting as well as an *amount* was mentioned, and in Chapter V.† on K.O. motion mention was made that every machine in both drawing and spinning may be used as a measuring machine for weight and length. To those in charge of drawing and spinning the phrases, “Turn-off of machines,” “Quantity of work done,” “Supply and Demand” will be quite familiar, but due to the disagreement between theory and practice, and the person-in-charge being practical, the former has been abandoned. The writer is convinced that both are correct in themselves, not only in the Textile Trade, but in all trades and professions.

The distance to a certain place is 120 miles. By travelling at the rate of 40 miles per hour, the place is reached in three hours. If the rate be 60 miles per hour, the destination will be reached in two hours. The *rate* causes the difference in the time taken to perform the journey.

The time required to spin a certain quantity depends on the rate. A G.B. in a drawing room runs at the rate of 100 lbs. per hour. In 47 hours it will deliver 4,700 lbs. of sliver, the amount for one week. The actual amount “turned-off” for a two months’ average was

\* P. 9, sect. 19.

† P. 46, sect. 62.



2,700 lbs., thus showing that the box only ran 27 out of a possible 47 hours. Not only is there an amount of production, but also a rate of production. One is accustomed to speak of "miles per hour," hence little difficulty should be experienced, in drawing and spinning, in speaking of lbs. per hour.

### 122. Spinning Frame (Cap, Flyer, or Ring).

Let  $W$  = weight in lbs. per hour (rate).

„  $H$  = hanks per lb. spinning.

„  $t$  = time in mins. run.

„  $n_R$  = r.p.m. of F.R.

„  $s$  = number of spindles.

„  $R$  = diam. in inches of F.R.

$$\text{Then } W = \frac{\pi R}{36} \frac{n_R s t}{560} \frac{1}{H} \quad . \quad . \quad . \quad . \quad . \quad (67)$$

$$\text{Hence } W = 1.559 \times 10^{-4} ; R n_R s t / H. \quad . \quad . \quad (68)$$

Substituting in (68)

$$t = 60 \text{ minutes} = 1 \text{ hour.}$$

$$\text{Then } W = 9.354 \times 10^{-3} R n_R s / H. \quad . \quad . \quad (69)$$

$$\text{Now let } h = 9.354 \times 10^{-3} R. \quad . \quad . \quad . \quad (70)$$

$$\text{Then } W = h n_R s / H. \quad . \quad . \quad . \quad . \quad (71)$$

TABLE XVI.

R.	h.
1	$9.354 \times 10^{-3}$
2	$1.870 \times 10^{-2}$
2.5	$2.337 \times 10^{-2}$
3	$2.805 \times 10^{-2}$
3.5	$3.273 \times 10^{-2}$
4	$3.741 \times 10^{-2}$
4.5	$4.208 \times 10^{-2}$
5	$4.677 \times 10^{-2}$

*Note.*—W will be production in lbs. per hour found by substituting the numerical values of  $h$  for the value R given in table XVI.

The value of  $n_r$  should *always* be counted in practice. This divided into  $N_r = 120$  K, giving minutes to run frame which can easily be tested and =  $t$ .

123. **An Orme's Indicator** registers the value of  $h$  per spindle, irrespective to time,  $t$ ,

where 
$$W = h s/H. \quad (72)$$

The mechanism of the afore-mentioned indicator is such that the *size* of F.R. must be stated when ordering.

An Orme's indicator was attached to a  $2\frac{1}{2}$ -inch F.R. of a Spinning Frame, the stamping on the instrument being :—

$$560 \times \frac{1}{39} \times \frac{3}{20} \times \frac{1}{10} \times \frac{1}{10}.$$

Now letting  $N_r$  = *total* number of revs. of F.R. to register 1 hank.

$$\text{Then } \frac{N_r}{39} \times \frac{3}{20} \times \frac{1}{10} = 1,$$

$$\therefore N_r = \frac{39 \times 20 \times 10}{3} = 2,600 \text{ revs.}$$

(*Note.*—The indicator stampings given are entirely from memory.)

$$\text{Now a } 2\frac{1}{2}\text{-inch F.R.} = \frac{2.5}{36 \times 560} \text{ hank.}$$

Let  $N_s$  = *total* revs. of F.R. to spin 1 hank.

$$\text{Then } \frac{2.5}{36 \times 560} N_s = 1.$$

$$\therefore N_s = \frac{36 \times 560}{2.5} = 2,566 \text{ revs. } \text{Ans.}$$

Hence the indicator for *this* size of F.R. registers  $2,600 - 2,566 = 34$  revs. in excess of those required to spin a hank.

124 *Worked Examples*.—1. A spinning frame is spinning 2/100's at 5 per cent. light. The diameter of F.R. is 2 inches, making 19 r.p.m., and the number of spindles is 156. Find the production in lbs. per hour.

Now counts,  $C = 100$ 's = 105 hanks per lb. =  $H$ .  
 $R = 2$ ;  $n_r = 19$ ; and  $s = 156$ .

Substitute in (71),

Where  $W = h n_r s / H$ .

Then  $W = 1.8700 \times 10^{-2} \times 19 \times 156 / 105$ .

$\therefore W = 0.5278$  lb. per hour. *Ans.*

2. 2/80's at 5 per cent. light are being spun on a spinning frame with 144 spindles. The F.R. diameter being 2.5" making 21 r.p.m. Find value of  $W$  per hour.

Now 5 per cent. of 80 = 4; therefore  $H = 84$ ;  $s = 144$ ;  
 $R = 2.5$ ; and  $n_r = 21$ .

Substituting in (71),

Where  $W = h n_r s / H$ .

Then  $W = 2.337 \times 10^{-2} \times 21 \times 144 / 84$ .

$\therefore W = 0.8414$  lb. per hour. *Ans.*

3. The following particulars are given for a spinning frame :—

$R = 3$ ;  $n_r = 26$ ;  $s = 162$ ; and  $C = 60$ 's at 5 per cent. light. Find value of  $W$  per hour.

Now 5 per cent. of 60 = 3; then  $H = 63$ .

Substituting in (71),

Where  $W = h n_r s / H$ .

Then  $W = 2.805 \times 10^{-2} \times 26 \times 162/63.$

$\therefore W = 1.876$  lbs. per hour. *Ans.*

4. Calculate the value of  $W$  per hour from the following particulars :— $s = 84$  ;  $n_r = 31$  ;  $R = 4$  ;  $C's = 36$  at 5 per cent. light. Hence  $H = 37.8.$

Substituting in (71),

Where  $W = h n_r s/H.$

Then  $W = 3.741 \times 10^{-2} \times 31 \times 84/37.8.$

$\therefore W = 2.577$  lbs. per hour. *Ans.*

5. If  $R = 5$  ;  $n_r = 37$  ;  $s = 158$  ; and  $C's = 24$  at 5 per cent. light ; hence  $H = 25.2.$  Find value of  $W$  per hour.

Substituting in (71),

Where  $W = h n_r s/H.$

Then  $W = 4.677 \times 10^{-2} \times 37 \times 158/25.2.$

$\therefore W = 10.85$  lbs. per hour. *Ans.*

Notice should be taken of the fact that formula (71) is particular, being derived from the general formula (67).

**125. Quantity and Weighing.**—In the trade, it is customary to receive orders for a definite quantity in lbs. to be spun of the counts required on one or more machines. Practice has evolved a method, convenient, no doubt, of weighing on a spring balance, the number of empty bobbins equal to number of spindles and the containing vessel (usually a tub), the weight of which is tare. A doff of full bobbins is then weighed in the tub, thus obtaining the gross weight. Taking the former from the latter, gives the nett weight per doff—*e.g.*, 240 lbs. are required of a certain count. Following the

procedure given, the nett weight is 8 lbs.; then  $240/8 = 30$  doffs. As there are 3 frames, 10 doffs are required per frame to complete the quantity of order given. The doffs would be marked on each frame or doffing sheet by spinner, head doffer, or taker-off.

126. With the aforesaid the author fully agrees, but due to the need of K.O. motion, and the necessity of having each machine fitted with some kind of K.O. motion, to eliminate dependence upon the human element to stop the machine at the correct point of time, thereby avoiding that confusion, waste, and loss of time, when a machine "runs over;" it is advisable to have a K.O. motion, which, due to its construction and mechanism, combines other advantages, such as are obtained in the 3-wheel type, thereby fulfilling the remarks made in the beginning of Chapter V.\*

There is yet another aspect to be considered where theory and practice do not always appear to agree, due to their respective applications being misapplied. To calculate the weight per doff is evaded for obvious reasons, and if attempted the result is discarded with an air of certainty of a better method. By using formula (67) the value of  $W$  per doff may be found.  $K$  will be some factor of counts,  $C$ , say  $\frac{3}{4} C = \frac{3}{4} H$ . The frame would be started and the time noted. Meanwhile the value of  $n_r$  would be found, as explained in Chapter V., subsequent to Formula (17);  $N_r$  by (14) or (15) and  $t$  by (17). Hence, all the numerical values of factors in (67) may be filled in and  $W$  per doff found. This result would be equal to the weight recorded by actual weighing on spring balance. This weight obtained is for actual time run.

\* P. 46, sect. 62.

For various counts, it will be made every half to five hours, allowing five minutes for an average doff, the time standing would vary from five to fifty minutes. This *must* be reckoned with for the various counts spun on *each* machine. The *rate* of production per hour multiplied by time per day, week, or month run may be called the **maximum**; there also remain the **working** and the **actual** production.

127. To derive a comprehensive formula for *rate of production* for the **cone and open drawing boxes, also gill boxes.**

Let  $R$  = diameter in inches of front roller.

„  $n_r$  = r.p.m. of F.R.

„  $s$  = number of spindles.

„  $t$  = time in minutes run.

„  $l$  = length of 80 yards of sliver.

„  $w$  = weight of 80 yards of sliver in drams.

„  $W$  = weight in lbs. in  $t$  minutes.

$$\text{„ } W = \frac{\pi R}{36} \frac{n_r s t}{256} \frac{w}{l} \quad . \quad . \quad . \quad . \quad . \quad . \quad (73)$$

$$\text{Hence } W = 3.410 \times 10^{-4} R n_r s t w / l, \quad . \quad . \quad . \quad . \quad (74)$$

Substituting in (74)

$$t = 60 \text{ mins.} = 1 \text{ hr.}$$

$$\text{Then } W = 2.046 \times 10^{-2} R n_r s w / l. \quad . \quad . \quad (75)$$

Substituting in (75)

$$l = 80 \text{ yards roving for } w \text{ drams.}$$

$$\text{Then } W = 2.558 \times 10^{-4} R n_r s w. \quad . \quad . \quad (76)$$

$$\text{Let } k = 2.558 \times 10^{-4} R. \quad . \quad . \quad . \quad . \quad (77)$$

$$\text{Then } W = k n_r s w. \quad . \quad . \quad . \quad . \quad (78)$$

TABLE XVII.

R.	k.
1	$2.558 \times 10^{-4}$
2	$5.114 \times 10^{-4}$
2.5	$6.393 \times 10^{-4}$
3	$7.672 \times 10^{-4}$
3.5	$8.952 \times 10^{-4}$
4	$1.023 \times 10^{-3}$
4.5	$1.151 \times 10^{-3}$
5	$1.278 \times 10^{-3}$

## WORKED EXAMPLES.

128.—1. **A Can Gill Box** is making 164 r.p.m. of the front roller, the diameter of which is 2 inches, the weight of sliver being 560 drams for 80 yards. It is required to find the *rate of production* per hour.

Now the value of  $k$  from the table for a 2-inch F.R. is  $5.114 \times 10^{-4}$ ;  $n_r = 164$ ;  $w = 560$ ; and  $s = 2$ .

Substituting in (78),

Where  $W = k n_r s w$ .

Then  $W = 5.114 \times 10^{-4} \times 164 \times 2 \times 560$ .

Hence  $W = 93.91$  lbs. per hour. *Ans.*

2. **A Spindle Gill Box** is making a sliver of 310 drams per 80 yards, diameter of front roller is  $2\frac{1}{2}$  inches making 112 r.p.m. Find rate of production per hour.

From above it will be seen  $w = 310$ ;  $n_r = 112$ ;  $s = 2$ ; and  $k$  from table equals  $6.393 \times 10^{-4}$ .

Substituting in (78),

Where  $W = k n_r s w$ .

Then  $W = 6.393 \times 10^{-4} \times 112 \times 2 \times 310$ .

Hence  $W = 44.39$  lbs. per hour. *Ans.*

3. **A 6-Spindle Drawing Box** making a sliver of 340 drams per 80 yards, and the 4-inch F.R. making 63 r.p.m. Find  $W$  per hour.

Now  $k = 1.023 \times 10^{-3}$ ;  $n_s = 63$ ;  $s = 6$ ; and  $w = 340$ .

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 63 \times 6 \times 340$ .

Hence  $W = 131.4$  lbs. per hour. *Ans.*

4. **A 6-Spindle Weigh Box** the particulars of which are  $R = 4$ ;  $w = 256$ ;  $n_s = 81$ ; Find value of  $W$  per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 81 \times 6 \times 256$ .

Hence  $W = 127.3$  lbs. per hour. *Ans.*

5. **An 8-Spindle 1st Finishing Box** has the following values :—

$w = 142$ ;  $n_s = 114$ ; and  $R = 4$ . Find  $W$  per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 114 \times 8 \times 142$ .

Hence  $W = 132.4$  lbs. per hour. *Ans.*

6. **Two 8-Spindle 2nd Finishing Boxes** the value of  $w = 81$ ;  $n_s = 96$ ; and  $R = 4$ . Find  $W$  per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 96 \times 16 \times 81$ .

Hence  $W = 127.3$  lbs. per hour. *Ans.*



7 (1) **Two 20-Spindle 1st Reducing Boxes** have the following dimensions:— $R = 4$ ;  $w = 44$ ;  $n_s = 59$ . Find value of  $W$  per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 59 \times 40 \times 44$ .

Hence  $W = 106.4$  lbs. per hour. *Ans.*

(2) **One 10-Spindle 1st Reducing Box** where  $w = 44$ ;  $n_s = 79$ ; and  $R = 4$ . Find value of  $W$  per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 79 \times 10 \times 44$ .

Hence  $W = 35.55$  lbs. per hour. *Ans.*

8. **Six 24-Spindle 2nd Reducing Boxes** making an average of 57 r.p.m. of F.R's. The weight of sliver being 17 drams per 80 yards.  $R = 4$ . Find production in lbs. per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 57 \times (6 \times 24) \times 17$ .

Hence  $W = 142.8$  lbs. per hour. *Ans.*

9. **Twenty-four 24-Spindle Roving Boxes** making 6 drams per 80 yards roving with an average F.R. speed of 39 r.p.m. and 4-inch diameter. Find the value of  $W$  per hour.

Substituting in (78),

Where  $W = k n_s s w$ .

Then  $W = 1.023 \times 10^{-3} \times 39 \times (24 \times 24) \times 6$ .

Hence  $W = 137.9$  lbs. per hour. *Ans.*

The examples given are for a large Botany set of Drawing ; with the exception of the Gill Boxes the front rollers are 4 inches in diameter. A careful examination of the numerical value of the constant  $k$  for a 4-inch front roller reveals the fact that it is  $1 \times 10^{-3}$  and correct to the third decimal place.

Hence  $W = k n_r s w = 1.023 \times 10^{-3} n_r s w = 1 \times 10^{-3} n_r s w$ .

The value of  $n_r$  should always be counted in practice.

**129. Rate of Production of Gill Boxes**, in this the value of  $R$  varies, hence constant  $k$  will alter for each altered value of  $R$ . In Chapter II., Table II., note the different values of  $R$  (circumference) for a 2-inch diameter front roller, Table III. for  $2\frac{1}{2}$  and 3 inch.

It does not require much mental effort to grasp the fact that a 2- or 3-inch diameter pinioned front roller will pay out *more than*  $2\pi$  or  $3\pi$  inches of sliver each revolution. The length in excess of  $\pi R$  delivered depends upon the thickness of Gill Leather and the pressure put upon it ; the thickness of the sliver being negligible.

Using the general formula (73).

$$\text{Where} \quad W = \frac{\pi R}{36} \frac{n_r s t}{256} \frac{w}{l}.$$

Substituting  $l = 80$  ;  $t = 60$  ; and  $s = 2$  for Can and Spindle Gill Boxes.

$$\text{Then} \quad W = 1.628 \times 10^{-4} R n_r w. \quad . \quad . \quad (79)$$

$$\text{Let } k_g = 1.628 \times 10^{-4} R. \quad . \quad . \quad . \quad (80)$$

(Subscript  $g$  indicates constant  $k$  for Gill Boxes.)

$$\text{Then} \quad W = k_g n_r w. \quad . \quad . \quad . \quad . \quad (81)$$

130.

TABLE XVIII.

$\pi R$	$k_g$	$\pi R$	$1/k_g$
$5\frac{1}{2}$	$8.954 \times 10^{-4}$	8	$1.302 \times 10^{-3}$
$5\frac{5}{8}$	$9.156 \times 10^{-4}$	$8\frac{1}{8}$	$1.322 \times 10^{-3}$
$5\frac{3}{4}$	$9.360 \times 10^{-4}$	$8\frac{1}{4}$	$1.343 \times 10^{-3}$
$5\frac{7}{8}$	$9.563 \times 10^{-4}$	$8\frac{3}{8}$	$1.363 \times 10^{-3}$
6	$9.766 \times 10^{-4}$	$8\frac{1}{2}$	$1.384 \times 10^{-3}$
$6\frac{1}{8}$	$9.970 \times 10^{-4}$	$8\frac{5}{8}$	$1.404 \times 10^{-3}$
$6\frac{1}{4}$	$1.017 \times 10^{-3}$	$8\frac{3}{4}$	$1.424 \times 10^{-3}$
$6\frac{3}{8}$	$1.038 \times 10^{-3}$	$8\frac{7}{8}$	$1.445 \times 10^{-3}$
$6\frac{1}{2}$	$1.058 \times 10^{-3}$	9	$1.465 \times 10^{-3}$
$6\frac{5}{8}$	$1.078 \times 10^{-3}$	$9\frac{1}{8}$	$1.486 \times 10^{-3}$
$6\frac{3}{4}$	$1.098 \times 10^{-3}$	$9\frac{1}{4}$	$1.505 \times 10^{-3}$
$6\frac{7}{8}$	$1.119 \times 10^{-3}$	$9\frac{3}{8}$	$1.526 \times 10^{-3}$
7	$1.140 \times 10^{-3}$	$9\frac{1}{2}$	$1.546 \times 10^{-3}$

## WORKED EXAMPLES.

131.—1. **A Can Gill Box** in a Botany sett of Drawing the front roller of which is making 115 r.p.m. The circumference being  $6\frac{7}{8}$  inches, and delivering a sliver 610 drams per 80 yards. It is required to find rate of production in lbs. per hour.

Substituting in (81)

Where  $W = k_g n_R w.$

Then  $W = 1.119 \times 10^{-3} \times 115 \times 610.$

Hence  $W = 78.47$  lbs. per hour. *Ans.*

2. **A Spindle Gill Box** the front roller of which is making 93 r.p.m. for  $8\frac{5}{8}$  inches circumference (working), and delivering a sliver 256 drams per 80 yards. Find the value of  $W$  lbs. per hour.

Substituting in (81)

Where  $W = k_g n_R w.$

Then  $W = 1.404 \times 10^{-3} \times 93 \times 256.$

Hence  $W = 72.59$  lbs. per hour. *Ans.*

132. Referring back to the general formula (67) and the special derived formula (71) for rate of production in lbs. per hour for spinning frames it will be further noticed that a new series of values for the constant  $h$  may be made with advantage as spinning frames are usually made for a fixed number of spindles according to requirements.

$$\text{Now} \quad W = h n_r s/H. \quad . \quad . \quad . \quad . \quad . \quad (71)$$

$$\text{Let} \quad h_s = h s. \quad . \quad . \quad . \quad . \quad . \quad (71a)$$

$$\text{Then} \quad W = h_s n_r/H. \quad . \quad . \quad . \quad . \quad . \quad (82)$$

#### WORKED EXAMPLES.

133. Find a particular formula for rate of production in lbs. per hour for spinning frames having 164 spindles, and 4-inch diameter front roller.

1. Substituting in (71)

$$\text{Where} \quad W = h n_r s/H.$$

$$\text{Then} \quad W = 3.741 \times 10^{-2} \times 164 n_r/H.$$

$$\text{Let} \quad h_s = 3.741 \times 10^{-2} \times 164 = 6.135 \times 10^0.$$

$$\text{Hence} \quad W = 6.135 n_r/H. \quad . \quad . \quad . \quad . \quad . \quad (83)$$

2. Substitute in (83)

$$n_r = 30 : \text{ and } H = 37.8.$$

$$\text{Then} \quad W = 6.135 \times 30/37.8.$$

$$\text{Hence} \quad W = 4.868 \text{ lbs. per hour. } \textit{Ans.}$$

3. The rate of production for a spinning frame is 4.868 lbs. per hour. The time run to fill a doff is two hours and twenty minutes. Find weight per doff.

$$\text{Weight per doff} = 4.868 \times 140/60 = 11.36 \text{ lbs. } \textit{Ans.}$$

134. This brings the reader to another series of formulæ for **weight per bobbin or doff** in both spinning and drawing. Their derivation depends upon the argument developed in Chapter V. on Knock-off Motion.

The *total* number of revolutions of front roller to fill a doff or a bobbin on a spinning frame was found to be

$$N_r = 120 K = n_r t.$$

Let  $W_d$  = weight in lbs. per  $s$  spindles per doff.  
(Total revs. of F.R. being  $N_r$ .)

„  $R$  = diameter of F.R. in inches.

„  $s$  = number of spindles.

„  $H$  = hanks per lb. spinning.

$$\text{Then } W_d = \frac{\pi R}{36} \frac{s}{560} \frac{N_r}{H} \dots \dots \dots (84)$$

Substitute in (84)

$120 K = N_r$  gives  $W_d$  in terms of  $K$ .

$$\text{Hence } W_d = \frac{\pi R}{36} \frac{s}{560} \frac{120}{H} K \dots \dots \dots (85)$$

$$\text{Now } W_d = 1.870 \times 10^{-2} R s K/H \dots \dots \dots (86)$$

$$\text{Let } h_d = 1.870 \times 10^{-2} R \dots \dots \dots (87)$$

$$\text{Then } W_d = h_d s K/H \dots \dots \dots (88)$$

By transposition in (88).

$$\text{Then } K = \frac{1}{h_d} \frac{H W_d}{s} \dots \dots \dots (89)$$

## SECTION 135.

TABLE XIX.

R	$h_d$	$1/h_d$
1	$1.870 \times 10^{-2}$	$5.347 \times 10^1$
2	$3.740 \times 10^{-2}$	$2.674 \times 10^1$
2.5	$4.675 \times 10^{-2}$	$2.139 \times 10^1$
3	$5.610 \times 10^{-2}$	$1.782 \times 10^1$
3.5	$6.545 \times 10^{-2}$	$1.528 \times 10^1$
4	$7.480 \times 10^{-2}$	$1.337 \times 10^1$
4.5	$8.415 \times 10^{-2}$	$1.188 \times 10^1$
5	$9.350 \times 10^{-2}$	$1.069 \times 10^1$

136. Eliminating  $s$  in (88).

Where  $W_d = h_d s K/H.$

Let  $h_d s = h_{ds}.$

*Note.*—The subscript letters  $ds$  indicate the constant,  $h$  is per doff  $d$ , and  $s$  number of spindles.

Then  $W_d = h_{ds} K/H. \quad . \quad . \quad . \quad . \quad . \quad (90)$

By transposition in (90).

Then  $K = \frac{1}{h_{ds}} H W_d. \quad . \quad . \quad . \quad . \quad . \quad (91)$

## 102 WORSTED DRAWING AND SPINNING CALCULATIONS.

## SECTION 137.

## TABLE XX.

R	s	$h_{ds}$	$1/h_{ds}$
2	100	$3.740 \times 10^0$	$2.674 \times 10^{-1}$
2	104	$3.890 \times 10^0$	$2.571 \times 10^{-1}$
2	108	$4.039 \times 10^0$	$2.476 \times 10^{-1}$
2	112	$4.189 \times 10^0$	$2.387 \times 10^{-1}$
2	116	$4.338 \times 10^0$	$2.304 \times 10^{-1}$
2	120	$4.488 \times 10^0$	$2.228 \times 10^{-1}$
2	* 124	$4.638 \times 10^0$	$2.156 \times 10^{-1}$
2	128	$4.787 \times 10^0$	$2.088 \times 10^{-1}$
2	132	$4.937 \times 10^0$	$2.025 \times 10^{-1}$
2	136	$5.086 \times 10^0$	$1.966 \times 10^{-1}$
2	140	$5.236 \times 10^0$	$1.910 \times 10^{-1}$
2	144	$5.386 \times 10^0$	$1.857 \times 10^{-1}$
2	148	$5.535 \times 10^0$	$1.806 \times 10^{-1}$
2	152	$5.685 \times 10^0$	$1.759 \times 10^{-1}$
2	156	$5.834 \times 10^0$	$1.714 \times 10^{-1}$
2	160	$5.984 \times 10^0$	$1.671 \times 10^{-1}$
2	164	$6.134 \times 10^0$	$1.630 \times 10^{-1}$
2	168	$6.283 \times 10^0$	$1.592 \times 10^{-1}$
2	172	$6.433 \times 10^0$	$1.554 \times 10^{-1}$
2	176	$6.582 \times 10^0$	$1.519 \times 10^{-1}$
2	180	$6.732 \times 10^0$	$1.486 \times 10^{-1}$
2	184	$6.882 \times 10^0$	$1.453 \times 10^{-1}$
2	188	$7.031 \times 10^0$	$1.422 \times 10^{-1}$
2	192	$7.181 \times 10^0$	$1.393 \times 10^{-1}$
2	196	$7.330 \times 10^0$	$1.364 \times 10^{-1}$
2	200	$7.480 \times 10^0$	$1.337 \times 10^{-1}$
2	204	$7.630 \times 10^0$	$1.311 \times 10^{-1}$
2	208	$7.779 \times 10^0$	$1.285 \times 10^{-1}$
2	212	$7.929 \times 10^0$	$1.261 \times 10^{-1}$
2	216	$8.078 \times 10^0$	$1.238 \times 10^{-1}$
2	220	$8.228 \times 10^0$	$1.215 \times 10^{-1}$
2	224	$8.378 \times 10^0$	$1.193 \times 10^{-1}$
2	228	$8.527 \times 10^0$	$1.173 \times 10^{-1}$
2	232	$8.677 \times 10^0$	$1.153 \times 10^{-1}$
2	236	$8.826 \times 10^0$	$1.133 \times 10^{-1}$
2	240	$8.976 \times 10^0$	$1.114 \times 10^{-1}$

TABLE XX.—*Continued.*

R	s	$h_{ds}$	$1/h_{ds}$
2.5	100	$4.676 \times 10^0$	$2.139 \times 10^{-1}$
2.5	104	$4.863 \times 10^0$	$2.057 \times 10^{-1}$
2.5	108	$5.050 \times 10^0$	$1.981 \times 10^{-1}$
2.5	112	$5.237 \times 10^0$	$1.910 \times 10^{-1}$
2.5	116	$5.424 \times 10^0$	$1.844 \times 10^{-1}$
2.5	120	$5.611 \times 10^0$	$1.782 \times 10^{-1}$
2.5	124	$5.798 \times 10^0$	$1.725 \times 10^{-1}$
2.5	128	$5.985 \times 10^0$	$1.671 \times 10^{-1}$
2.5	132	$6.172 \times 10^0$	$1.620 \times 10^{-1}$
2.5	136	$6.359 \times 10^0$	$1.572 \times 10^{-1}$
2.5	140	$6.546 \times 10^0$	$1.528 \times 10^{-1}$
2.5	144	$6.733 \times 10^0$	$1.486 \times 10^{-1}$
2.5	148	$6.920 \times 10^0$	$1.445 \times 10^{-1}$
2.5	152	$7.107 \times 10^0$	$1.407 \times 10^{-1}$
2.5	156	$7.294 \times 10^0$	$1.371 \times 10^{-1}$
2.5	160	$7.481 \times 10^0$	$1.337 \times 10^{-1}$
2.5	164	$7.668 \times 10^0$	$1.304 \times 10^{-1}$
2.5	168	$7.854 \times 10^0$	$1.274 \times 10^{-1}$
2.5	172	$8.041 \times 10^0$	$1.244 \times 10^{-1}$
2.5	176	$8.228 \times 10^0$	$1.215 \times 10^{-1}$
2.5	180	$8.415 \times 10^0$	$1.188 \times 10^{-1}$
2.5	184	$8.602 \times 10^0$	$1.162 \times 10^{-1}$
2.5	188	$8.789 \times 10^0$	$1.138 \times 10^{-1}$
2.5	192	$8.976 \times 10^0$	$1.114 \times 10^{-1}$
2.5	196	$9.163 \times 10^0$	$1.091 \times 10^{-1}$
2.5	200	$9.350 \times 10^0$	$1.069 \times 10^{-1}$
2.5	204	$9.537 \times 10^0$	$1.048 \times 10^{-1}$
2.5	208	$9.724 \times 10^0$	$1.028 \times 10^{-1}$
2.5	212	$9.911 \times 10^0$	$1.009 \times 10^{-1}$
2.5	216	$1.010 \times 10^1$	$9.902 \times 10^{-2}$
2.5	220	$1.029 \times 10^1$	$9.723 \times 10^{-2}$
2.5	224	$1.047 \times 10^1$	$9.550 \times 10^{-2}$
2.5	228	$1.066 \times 10^1$	$9.382 \times 10^{-2}$
2.5	232	$1.085 \times 10^1$	$9.219 \times 10^{-2}$
2.5	236	$1.103 \times 10^1$	$9.066 \times 10^{-2}$
2.5	240	$1.122 \times 10^1$	$8.913 \times 10^{-2}$



TABLE XX.—*Continued.*

R	s	$h_{ds}$	$1/h_{ds}$
3	100	$5.610 \times 10^0$	$1.782 \times 10^{-1}$
3	104	$5.835 \times 10^0$	$1.714 \times 10^{-1}$
3	108	$6.059 \times 10^0$	$1.650 \times 10^{-1}$
3	112	$6.284 \times 10^0$	$1.592 \times 10^{-1}$
3	116	$6.508 \times 10^0$	$1.537 \times 10^{-1}$
3	120	$6.733 \times 10^0$	$1.486 \times 10^{-1}$
3	124	$6.957 \times 10^0$	$1.437 \times 10^{-1}$
3	128	$7.182 \times 10^0$	$1.393 \times 10^{-1}$
3	132	$7.407 \times 10^0$	$1.350 \times 10^{-1}$
3	136	$7.631 \times 10^0$	$1.311 \times 10^{-1}$
3	140	$7.856 \times 10^0$	$1.274 \times 10^{-1}$
3	144	$8.080 \times 10^0$	$1.238 \times 10^{-1}$
3	148	$8.305 \times 10^0$	$1.204 \times 10^{-1}$
3	152	$8.529 \times 10^0$	$1.173 \times 10^{-1}$
3	156	$8.754 \times 10^0$	$1.142 \times 10^{-1}$
3	160	$8.979 \times 10^0$	$1.114 \times 10^{-1}$
3	164	$9.203 \times 10^0$	$1.086 \times 10^{-1}$
3	168	$9.428 \times 10^0$	$1.061 \times 10^{-1}$
3	172	$9.652 \times 10^0$	$1.036 \times 10^{-1}$
3	176	$9.877 \times 10^0$	$1.013 \times 10^{-1}$
3	180	$1.010 \times 10^1$	$9.902 \times 10^{-2}$
3	184	$1.033 \times 10^1$	$9.687 \times 10^{-2}$
3	188	$1.055 \times 10^1$	$9.479 \times 10^{-2}$
3	192	$1.078 \times 10^1$	$9.283 \times 10^{-2}$
3	196	$1.100 \times 10^1$	$9.093 \times 10^{-2}$
3	200	$1.122 \times 10^1$	$8.913 \times 10^{-2}$
3	204	$1.145 \times 10^1$	$8.738 \times 10^{-2}$
3	208	$1.167 \times 10^1$	$8.569 \times 10^{-2}$
3	212	$1.190 \times 10^1$	$8.409 \times 10^{-2}$
3	216	$1.212 \times 10^1$	$8.250 \times 10^{-2}$
3	220	$1.235 \times 10^1$	$8.102 \times 10^{-2}$
3	224	$1.257 \times 10^1$	$7.958 \times 10^{-2}$
3	228	$1.280 \times 10^1$	$7.818 \times 10^{-2}$
3	232	$1.302 \times 10^1$	$7.683 \times 10^{-2}$
3	236	$1.325 \times 10^1$	$7.553 \times 10^{-2}$
3	240	$1.347 \times 10^1$	$7.427 \times 10^{-2}$

TABLE XX.—*Continued.*

R	s	$h_{ds}$	$1/h_{ds}$
3.5	100	$6.546 \times 10^0$	$1.528 \times 10^{-1}$
3.5	104	$6.808 \times 10^0$	$1.469 \times 10^{-1}$
3.5	108	$7.070 \times 10^0$	$1.415 \times 10^{-1}$
3.5	112	$7.331 \times 10^0$	$1.364 \times 10^{-1}$
3.5	116	$7.593 \times 10^0$	$1.317 \times 10^{-1}$
3.5	120	$7.855 \times 10^0$	$1.273 \times 10^{-1}$
3.5	124	$8.117 \times 10^0$	$1.232 \times 10^{-1}$
3.5	128	$8.379 \times 10^0$	$1.193 \times 10^{-1}$
3.5	132	$8.641 \times 10^0$	$1.157 \times 10^{-1}$
3.5	136	$8.902 \times 10^0$	$1.123 \times 10^{-1}$
3.5	140	$9.164 \times 10^0$	$1.091 \times 10^{-1}$
3.5	144	$9.426 \times 10^0$	$1.060 \times 10^{-1}$
3.5	148	$9.688 \times 10^0$	$1.032 \times 10^{-1}$
3.5	152	$9.950 \times 10^0$	$1.005 \times 10^{-1}$
3.5	156	$1.021 \times 10^1$	$9.792 \times 10^{-2}$
3.5	160	$1.047 \times 10^1$	$9.548 \times 10^{-2}$
3.5	164	$1.073 \times 10^1$	$9.315 \times 10^{-2}$
3.5	168	$1.100 \times 10^1$	$9.093 \times 10^{-2}$
3.5	172	$1.126 \times 10^1$	$8.882 \times 10^{-2}$
3.5	176	$1.152 \times 10^1$	$8.680 \times 10^{-2}$
3.5	180	$1.178 \times 10^1$	$8.486 \times 10^{-2}$
3.5	184	$1.204 \times 10^1$	$8.303 \times 10^{-2}$
3.5	188	$1.231 \times 10^1$	$8.125 \times 10^{-2}$
3.5	192	$1.257 \times 10^1$	$7.956 \times 10^{-2}$
3.5	196	$1.283 \times 10^1$	$7.793 \times 10^{-2}$
3.5	200	$1.309 \times 10^1$	$7.638 \times 10^{-2}$
3.5	204	$1.335 \times 10^1$	$7.489 \times 10^{-2}$
3.5	208	$1.362 \times 10^1$	$7.344 \times 10^{-2}$
3.5	212	$1.388 \times 10^1$	$7.206 \times 10^{-2}$
3.5	216	$1.414 \times 10^1$	$7.071 \times 10^{-2}$
3.5	220	$1.440 \times 10^1$	$6.944 \times 10^{-2}$
3.5	224	$1.466 \times 10^1$	$6.821 \times 10^{-2}$
3.5	228	$1.492 \times 10^1$	$6.701 \times 10^{-2}$
3.5	232	$1.519 \times 10^1$	$6.585 \times 10^{-2}$
3.5	236	$1.545 \times 10^1$	$6.473 \times 10^{-2}$
3.5	240	$1.571 \times 10^1$	$6.365 \times 10^{-2}$

TABLE XX.—*Continued.*

R	s	$h_{ds}$	$1/h_{ds}$
4	100	$7.480 \times 10^0$	$1.337 \times 10^{-1}$
4	104	$7.779 \times 10^0$	$1.285 \times 10^{-1}$
4	108	$8.079 \times 10^0$	$1.238 \times 10^{-1}$
4	112	$8.378 \times 10^0$	$1.193 \times 10^{-1}$
4	116	$8.678 \times 10^0$	$1.152 \times 10^{-1}$
4	120	$8.977 \times 10^0$	$1.114 \times 10^{-1}$
4	124	$9.276 \times 10^0$	$1.077 \times 10^{-1}$
4	128	$9.575 \times 10^0$	$1.044 \times 10^{-1}$
4	132	$9.875 \times 10^0$	$1.013 \times 10^{-1}$
4	136	$1.017 \times 10^1$	$9.828 \times 10^{-2}$
4	140	$1.047 \times 10^1$	$9.547 \times 10^{-2}$
4	144	$1.077 \times 10^1$	$9.281 \times 10^{-2}$
4	148	$1.107 \times 10^1$	$9.031 \times 10^{-2}$
4	152	$1.137 \times 10^1$	$8.794 \times 10^{-2}$
4	156	$1.167 \times 10^1$	$8.569 \times 10^{-2}$
4	160	$1.197 \times 10^1$	$8.354 \times 10^{-2}$
4	164	$1.227 \times 10^1$	$8.151 \times 10^{-2}$
4	168	$1.257 \times 10^1$	$7.956 \times 10^{-2}$
4	172	$1.287 \times 10^1$	$7.771 \times 10^{-2}$
4	176	$1.317 \times 10^1$	$7.595 \times 10^{-2}$
4	180	$1.347 \times 10^1$	$7.425 \times 10^{-2}$
4	184	$1.377 \times 10^1$	$7.264 \times 10^{-2}$
4	188	$1.407 \times 10^1$	$7.109 \times 10^{-2}$
4	192	$1.437 \times 10^1$	$6.961 \times 10^{-2}$
4	196	$1.467 \times 10^1$	$6.819 \times 10^{-2}$
4	200	$1.497 \times 10^1$	$6.683 \times 10^{-2}$
4	204	$1.527 \times 10^1$	$6.552 \times 10^{-2}$
4	208	$1.556 \times 10^1$	$6.425 \times 10^{-2}$
4	212	$1.586 \times 10^1$	$6.305 \times 10^{-2}$
4	216	$1.616 \times 10^1$	$6.187 \times 10^{-2}$
4	220	$1.646 \times 10^1$	$6.075 \times 10^{-2}$
4	224	$1.676 \times 10^1$	$5.968 \times 10^{-2}$
4	228	$1.706 \times 10^1$	$5.862 \times 10^{-2}$
4	232	$1.736 \times 10^1$	$5.761 \times 10^{-2}$
4	236	$1.766 \times 10^1$	$5.663 \times 10^{-2}$
4	240	$1.796 \times 10^1$	$5.569 \times 10^{-2}$

TABLE XX.—*Continued.*

R	s	$h_{ds}$	$1/h_{ds}$
4.5	100	$8.416 \times 10^0$	$1.188 \times 10^{-1}$
4.5	104	$8.752 \times 10^0$	$1.142 \times 10^{-1}$
4.5	108	$9.088 \times 10^0$	$1.100 \times 10^{-1}$
4.5	112	$9.424 \times 10^0$	$1.061 \times 10^{-1}$
4.5	116	$9.760 \times 10^0$	$1.024 \times 10^{-1}$
4.5	120	$1.010 \times 10^1$	$9.902 \times 10^{-2}$
4.5	124	$1.043 \times 10^1$	$9.583 \times 10^{-2}$
4.5	128	$1.077 \times 10^1$	$9.283 \times 10^{-2}$
4.5	132	$1.110 \times 10^1$	$9.001 \times 10^{-2}$
4.5	136	$1.144 \times 10^1$	$8.738 \times 10^{-2}$
4.5	140	$1.178 \times 10^1$	$8.487 \times 10^{-2}$
4.5	144	$1.211 \times 10^1$	$8.250 \times 10^{-2}$
4.5	148	$1.245 \times 10^1$	$8.028 \times 10^{-2}$
4.5	152	$1.278 \times 10^1$	$7.818 \times 10^{-2}$
4.5	156	$1.312 \times 10^1$	$7.617 \times 10^{-2}$
4.5	160	$1.346 \times 10^1$	$7.427 \times 10^{-2}$
4.5	164	$1.379 \times 10^1$	$7.246 \times 10^{-2}$
4.5	168	$1.413 \times 10^1$	$7.073 \times 10^{-2}$
4.5	172	$1.447 \times 10^1$	$6.908 \times 10^{-2}$
4.5	176	$1.480 \times 10^1$	$6.751 \times 10^{-2}$
4.5	180	$1.514 \times 10^1$	$6.601 \times 10^{-2}$
4.5	184	$1.547 \times 10^1$	$6.459 \times 10^{-2}$
4.5	188	$1.581 \times 10^1$	$6.320 \times 10^{-2}$
4.5	192	$1.615 \times 10^1$	$6.189 \times 10^{-2}$
4.5	196	$1.648 \times 10^1$	$6.061 \times 10^{-2}$
4.5	200	$1.682 \times 10^1$	$5.941 \times 10^{-2}$
4.5	204	$1.715 \times 10^1$	$5.825 \times 10^{-2}$
4.5	208	$1.749 \times 10^1$	$5.712 \times 10^{-2}$
4.5	212	$1.783 \times 10^1$	$5.602 \times 10^{-2}$
4.5	216	$1.816 \times 10^1$	$5.500 \times 10^{-2}$
4.5	220	$1.850 \times 10^1$	$5.401 \times 10^{-2}$
4.5	224	$1.884 \times 10^1$	$5.306 \times 10^{-2}$
4.5	228	$1.917 \times 10^1$	$5.212 \times 10^{-2}$
4.5	232	$1.951 \times 10^1$	$5.122 \times 10^{-2}$
4.5	236	$1.984 \times 10^1$	$5.035 \times 10^{-2}$
4.5	240	$2.018 \times 10^1$	$4.951 \times 10^{-2}$

TABLE XX.—*Continued.*

R	s	$h_{ds}$	$1/h_{ds}$
5	100	$9.350 \times 10^0$	$1.069 \times 10^{-1}$
5	104	$9.724 \times 10^0$	$1.028 \times 10^{-1}$
5	108	$1.010 \times 10^1$	$9.902 \times 10^{-2}$
5	112	$1.047 \times 10^1$	$9.548 \times 10^{-2}$
5	116	$1.085 \times 10^1$	$9.217 \times 10^{-2}$
5	120	$1.122 \times 10^1$	$8.910 \times 10^{-2}$
5	124	$1.160 \times 10^1$	$8.624 \times 10^{-2}$
5	128	$1.197 \times 10^1$	$8.354 \times 10^{-2}$
5	132	$1.234 \times 10^1$	$8.100 \times 10^{-2}$
5	136	$1.272 \times 10^1$	$7.863 \times 10^{-2}$
5	140	$1.309 \times 10^1$	$7.638 \times 10^{-2}$
5	144	$1.347 \times 10^1$	$7.425 \times 10^{-2}$
5	148	$1.384 \times 10^1$	$7.224 \times 10^{-2}$
5	152	$1.422 \times 10^1$	$7.036 \times 10^{-2}$
5	156	$1.459 \times 10^1$	$6.855 \times 10^{-2}$
5	160	$1.496 \times 10^1$	$6.683 \times 10^{-2}$
5	164	$1.534 \times 10^1$	$6.521 \times 10^{-2}$
5	168	$1.571 \times 10^1$	$6.363 \times 10^{-2}$
5	172	$1.609 \times 10^1$	$6.218 \times 10^{-2}$
5	176	$1.646 \times 10^1$	$6.075 \times 10^{-2}$
5	180	$1.684 \times 10^1$	$5.940 \times 10^{-2}$
5	184	$1.721 \times 10^1$	$5.812 \times 10^{-2}$
5	188	$1.758 \times 10^1$	$5.687 \times 10^{-2}$
5	192	$1.796 \times 10^1$	$5.569 \times 10^{-2}$
5	196	$1.833 \times 10^1$	$5.455 \times 10^{-2}$
5	200	$1.870 \times 10^1$	$5.347 \times 10^{-2}$
5	204	$1.908 \times 10^1$	$5.242 \times 10^{-2}$
5	208	$1.946 \times 10^1$	$5.140 \times 10^{-2}$
5	212	$1.983 \times 10^1$	$5.044 \times 10^{-2}$
5	216	$2.020 \times 10^1$	$4.950 \times 10^{-2}$
5	220	$2.058 \times 10^1$	$4.861 \times 10^{-2}$
5	224	$2.095 \times 10^1$	$4.774 \times 10^{-2}$
5	228	$2.132 \times 10^1$	$4.690 \times 10^{-2}$
5	232	$2.170 \times 10^1$	$4.609 \times 10^{-2}$
5	236	$2.207 \times 10^1$	$4.531 \times 10^{-2}$
5	240	$2.245 \times 10^1$	$4.455 \times 10^{-2}$

## WORKED EXAMPLES.

138.—1. A spinning frame with a 4-inch diameter F.R. ; 164 spindles ; spinning 30's, 5 per cent. light, has a K.O. change wheel of 51 teeth with two pegs in gear. Find weight in lbs. per doff.

Then  $R = 4$  ;  $s = 164$  ;  $K = 51/2$  ; and  $H = 30$  plus 5 per cent.  $= 31.5$ .

Substituting in (90).

Where  $W_d = h_{ds} K/H$ . (Note.—Value of  $h_{ds}$  given in Table XX. for  $s$  and  $R$ ).

Then  $W_d = 1.227 \times 10^1 \times \frac{51}{2} \frac{1}{31.5}$ .

Hence  $W_d = 9.933$  lbs. *Ans.*

2. The following particulars are given. Find value of  $K$ .

$H = 31.5$  ;  $s = 164$  ;  $R = 4$  ; and  $W_d = 10.5$ .

Substituting in (91).

Where  $K = \frac{1}{h_{ds}} \frac{H W_d}{1}$ .

Then  $K = 8.151 \times 10^{-2} \times 31.5 \times 10.5$ .

Hence  $K = 27$  for single peg wheel and 54 for double peg wheel.

3. Find the value of  $K$  when  $R = 4$  ;  $s = 164$  ;  $H = 37.8$  ; and  $W_d = 11.36$ .

Substituting in (91).

Where  $K = 1/h_{ds} H W_d$ .

Then  $K = 8.151 \times 10^{-2} \times 37.8 \times 11.36$ .

Hence  $K = 35$  for single peg wheel and  $K = 7$  for double peg wheel. *Ans.*

# 110 WORSTED DRAWING AND SPINNING CALCULATIONS.

139. To derive a comprehensive formula for **weight per doff on gill boxes**, and K.O. change wheel for a given weight.

Let  $W_g$  = weight in lbs. per doff on C.G.B. for *two* ends.

„  $W_g$  = weight in lbs. per doff on S.G.B. for *two* spindles.

„  $K$  = number of teeth in K.O. change wheel for 3-wheel type.

„  $R$  = diameter in inches of F.R. Hence  $\pi R$  = circumference.

„  $N_R$  = *total* number of revolutions of F.R. per doff.

„  $l$  = length of sliver in yards per  $w$  drams.

„  $w$  = weight of sliver in drams per  $l$  yards.

$$\text{Then} \quad W_u = \frac{\pi R}{36} \cdot \frac{s N_R}{256} \cdot \frac{w}{l} \quad . \quad . \quad . \quad (100)$$

$$\text{But} \quad N_R = d K \quad . \quad . \quad . \quad . \quad . \quad . \quad (19_1)$$

Substituting (19<sub>1</sub>) in (100).

$$\text{Then} \quad W_u = \frac{\pi R}{36} \cdot \frac{s d K}{256} \cdot \frac{w}{l} \quad . \quad . \quad . \quad . \quad . \quad (101)$$

Substituting in (101).

Where  $s = 2$  and  $l = 80$ .

$$\text{Then} \quad W_u = 2.712 \times 10^{-6} \pi R d K w \quad . \quad (102)$$

$$\text{Let} \quad k_u = 2.712 \times 10^{-6} \pi R \quad . \quad . \quad . \quad . \quad (103)$$

$$\text{Then} \quad W_u = k_u d K w \quad . \quad . \quad . \quad . \quad . \quad (104)$$

By transposition in (104).

$$\text{Then} \quad K = \frac{1}{k_u} \cdot \frac{W_u}{d w} \quad . \quad . \quad . \quad . \quad . \quad (105)$$

$$\text{And} \quad w = \frac{1}{k_u} \cdot \frac{W_u}{d K} \quad . \quad . \quad . \quad . \quad . \quad (106)$$

## SECTION 140.

TABLE XXI.

$\pi R$	$k_a$	$1/k_a$
$5\frac{1}{2}$	$1.492 \times 10^{-5}$	$6.702 \times 10^4$
$5\frac{3}{8}$	$1.526 \times 10^{-5}$	$6.554 \times 10^4$
$5\frac{1}{2}$	$1.560 \times 10^{-5}$	$6.410 \times 10^4$
$5\frac{7}{8}$	$1.593 \times 10^{-5}$	$6.275 \times 10^4$
6	$1.628 \times 10^{-5}$	$6.144 \times 10^4$
$6\frac{1}{8}$	$1.662 \times 10^{-5}$	$6.019 \times 10^4$
$6\frac{1}{2}$	$1.695 \times 10^{-5}$	$5.898 \times 10^4$
$6\frac{3}{8}$	$1.729 \times 10^{-5}$	$5.784 \times 10^4$
$6\frac{1}{2}$	$1.763 \times 10^{-5}$	$5.671 \times 10^4$
$6\frac{5}{8}$	$1.797 \times 10^{-5}$	$5.564 \times 10^4$
$6\frac{3}{4}$	$1.831 \times 10^{-5}$	$5.462 \times 10^4$
$6\frac{7}{8}$	$1.865 \times 10^{-5}$	$5.362 \times 10^4$
7	$1.899 \times 10^{-5}$	$5.266 \times 10^4$
8	$2.170 \times 10^{-5}$	$4.608 \times 10^4$
$8\frac{1}{8}$	$2.204 \times 10^{-5}$	$4.536 \times 10^4$
$8\frac{1}{4}$	$2.238 \times 10^{-5}$	$4.468 \times 10^4$
$8\frac{3}{8}$	$2.272 \times 10^{-5}$	$4.401 \times 10^4$
$8\frac{1}{2}$	$2.306 \times 10^{-5}$	$4.337 \times 10^4$
$8\frac{5}{8}$	$2.340 \times 10^{-5}$	$4.274 \times 10^4$
$8\frac{3}{4}$	$2.374 \times 10^{-5}$	$4.213 \times 10^4$
$8\frac{7}{8}$	$2.408 \times 10^{-5}$	$4.155 \times 10^4$
9	$2.442 \times 10^{-5}$	$4.097 \times 10^4$
$9\frac{1}{8}$	$2.476 \times 10^{-5}$	$4.040 \times 10^4$
$9\frac{1}{4}$	$2.510 \times 10^{-5}$	$3.986 \times 10^4$
$9\frac{3}{8}$	$2.544 \times 10^{-5}$	$3.932 \times 10^4$
$9\frac{1}{2}$	$2.577 \times 10^{-5}$	$3.881 \times 10^4$

141. Eliminate  $d$  in (104), (105), and (106).

Let  $k_{ad} = k_a d$ . Then (104) will be

$$W_a = k_{ad} K w. \quad . \quad . \quad . \quad . \quad . \quad (107)$$

And (105) will be

$$K = 1/k_{ad} W_a/w. \quad . \quad . \quad . \quad . \quad . \quad (108)$$

And (106) will be

$$w = 1/k_{ad} W_a/K. \quad . \quad . \quad . \quad . \quad . \quad (109)$$

Substitute in (107) (108), and (109) the numerical value of  $d = 39, 41, 59, 60, 61, 80, \text{ and } 81$ . (See Chap. V., Table XII.).



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## SECTION 142.

## TABLE XXII.

$d$	$\pi R$	$k_{ed}$	$1/k_{ed}$
39	$5\frac{1}{2}$	$5.820 \times 10^{-4}$	$1.718 \times 10^3$
41	$5\frac{1}{2}$	$6.117 \times 10^{-4}$	$1.635 \times 10^3$
59	$5\frac{1}{2}$	$8.804 \times 10^{-4}$	$1.136 \times 10^3$
60	$5\frac{1}{2}$	$8.954 \times 10^{-4}$	$1.117 \times 10^3$
61	$5\frac{1}{2}$	$9.101 \times 10^{-4}$	$1.098 \times 10^3$
80	$5\frac{1}{2}$	$1.193 \times 10^{-3}$	$8.377 \times 10^2$
81	$5\frac{1}{2}$	$1.209 \times 10^{-3}$	$8.273 \times 10^2$
39	$5\frac{5}{8}$	$5.951 \times 10^{-4}$	$1.681 \times 10^3$
41	$5\frac{5}{8}$	$6.256 \times 10^{-4}$	$1.599 \times 10^3$
59	$5\frac{5}{8}$	$9.003 \times 10^{-4}$	$1.111 \times 10^3$
60	$5\frac{5}{8}$	$9.156 \times 10^{-4}$	$1.092 \times 10^3$
61	$5\frac{5}{8}$	$9.307 \times 10^{-4}$	$1.074 \times 10^3$
80	$5\frac{5}{8}$	$1.221 \times 10^{-3}$	$8.193 \times 10^2$
81	$5\frac{5}{8}$	$1.236 \times 10^{-3}$	$8.091 \times 10^2$
39	$5\frac{3}{4}$	$6.084 \times 10^{-4}$	$1.644 \times 10^3$
41	$5\frac{3}{4}$	$6.396 \times 10^{-4}$	$1.563 \times 10^3$
59	$5\frac{3}{4}$	$9.204 \times 10^{-4}$	$1.086 \times 10^3$
60	$5\frac{3}{4}$	$9.361 \times 10^{-4}$	$1.069 \times 10^3$
61	$5\frac{3}{4}$	$9.515 \times 10^{-4}$	$1.051 \times 10^3$
80	$5\frac{3}{4}$	$1.248 \times 10^{-3}$	$8.013 \times 10^2$
81	$5\frac{3}{4}$	$1.264 \times 10^{-3}$	$7.914 \times 10^2$
39	$5\frac{7}{8}$	$6.216 \times 10^{-4}$	$1.609 \times 10^3$
41	$5\frac{7}{8}$	$6.534 \times 10^{-4}$	$1.531 \times 10^3$
59	$5\frac{7}{8}$	$9.404 \times 10^{-4}$	$1.064 \times 10^3$
60	$5\frac{7}{8}$	$9.563 \times 10^{-4}$	$1.046 \times 10^3$
61	$5\frac{7}{8}$	$9.721 \times 10^{-4}$	$1.029 \times 10^3$
80	$5\frac{7}{8}$	$1.275 \times 10^{-3}$	$7.843 \times 10^2$
81	$5\frac{7}{8}$	$1.291 \times 10^{-3}$	$7.747 \times 10^2$

TABLE XXII.—Continued.

$d$	$\pi R$	$k_{ad}$	$1/k_{ad}$
39	6	$6.349 \times 10^{-4}$	$1.575 \times 10^3$
41	6	$6.674 \times 10^{-4}$	$1.498 \times 10^3$
59	6	$9.605 \times 10^{-4}$	$1.041 \times 10^3$
60	6	$9.745 \times 10^{-4}$	$1.023 \times 10^3$
61	6	$9.928 \times 10^{-4}$	$1.007 \times 10^3$
80	6	$1.302 \times 10^{-3}$	$7.679 \times 10^2$
81	6	$1.318 \times 10^{-3}$	$7.584 \times 10^2$
39	$6\frac{1}{8}$	$6.480 \times 10^{-4}$	$1.543 \times 10^3$
41	$6\frac{1}{8}$	$6.813 \times 10^{-4}$	$1.468 \times 10^3$
59	$6\frac{1}{8}$	$9.804 \times 10^{-4}$	$1.020 \times 10^3$
60	$6\frac{1}{8}$	$9.970 \times 10^{-4}$	$1.003 \times 10^3$
61	$6\frac{1}{8}$	$1.014 \times 10^{-3}$	$9.868 \times 10^2$
80	$6\frac{1}{8}$	$1.329 \times 10^{-3}$	$7.523 \times 10^2$
81	$6\frac{1}{8}$	$1.346 \times 10^{-3}$	$7.430 \times 10^2$
39	$6\frac{1}{4}$	$6.613 \times 10^{-4}$	$1.512 \times 10^3$
41	$6\frac{1}{4}$	$6.952 \times 10^{-4}$	$1.438 \times 10^3$
59	$6\frac{1}{4}$	$1.000 \times 10^{-3}$	$9.995 \times 10^2$
60	$6\frac{1}{4}$	$1.017 \times 10^{-3}$	$9.828 \times 10^2$
61	$6\frac{1}{4}$	$1.034 \times 10^{-3}$	$9.670 \times 10^2$
80	$6\frac{1}{4}$	$1.356 \times 10^{-3}$	$7.372 \times 10^2$
81	$6\frac{1}{4}$	$1.374 \times 10^{-3}$	$7.281 \times 10^2$
39	$6\frac{3}{8}$	$6.744 \times 10^{-4}$	$1.483 \times 10^3$
41	$6\frac{3}{8}$	$7.089 \times 10^{-4}$	$1.410 \times 10^3$
59	$6\frac{3}{8}$	$1.021 \times 10^{-3}$	$9.802 \times 10^2$
60	$6\frac{3}{8}$	$1.038 \times 10^{-3}$	$9.638 \times 10^2$
61	$6\frac{3}{8}$	$1.054 \times 10^{-3}$	$9.482 \times 10^2$
80	$6\frac{3}{8}$	$1.384 \times 10^{-3}$	$7.230 \times 10^2$
81	$6\frac{3}{8}$	$1.401 \times 10^{-3}$	$7.141 \times 10^2$

TABLE XXII.—*Continued.*

$d$	$\pi R$	$k_{gd}$	$1/k_{gd}$
39	$6\frac{1}{2}$	$6.877 \times 10^{-4}$	$1.454 \times 10^3$
41	$6\frac{1}{2}$	$7.230 \times 10^{-4}$	$1.383 \times 10^3$
59	$6\frac{1}{2}$	$1.040 \times 10^{-3}$	$9.612 \times 10^2$
60	$6\frac{1}{2}$	$1.058 \times 10^{-3}$	$9.452 \times 10^2$
61	$6\frac{1}{2}$	$1.075 \times 10^{-3}$	$9.298 \times 10^2$
80	$6\frac{1}{2}$	$1.409 \times 10^{-3}$	$7.089 \times 10^2$
81	$6\frac{1}{2}$	$1.429 \times 10^{-3}$	$7.001 \times 10^2$
39	$6\frac{5}{8}$	$7.009 \times 10^{-4}$	$1.427 \times 10^3$
41	$6\frac{5}{8}$	$7.369 \times 10^{-4}$	$1.357 \times 10^3$
59	$6\frac{5}{8}$	$1.060 \times 10^{-3}$	$9.430 \times 10^2$
60	$6\frac{5}{8}$	$1.078 \times 10^{-3}$	$9.272 \times 10^2$
61	$6\frac{5}{8}$	$1.096 \times 10^{-3}$	$9.122 \times 10^2$
80	$6\frac{5}{8}$	$1.437 \times 10^{-3}$	$6.955 \times 10^2$
81	$6\frac{5}{8}$	$1.455 \times 10^{-3}$	$6.869 \times 10^2$
39	$6\frac{3}{4}$	$7.138 \times 10^{-4}$	$1.401 \times 10^3$
41	$6\frac{3}{4}$	$7.506 \times 10^{-4}$	$1.332 \times 10^3$
59	$6\frac{3}{4}$	$1.080 \times 10^{-3}$	$9.258 \times 10^2$
60	$6\frac{3}{4}$	$1.098 \times 10^{-3}$	$9.103 \times 10^2$
61	$6\frac{3}{4}$	$1.116 \times 10^{-3}$	$8.956 \times 10^2$
80	$6\frac{3}{4}$	$1.464 \times 10^{-3}$	$6.828 \times 10^2$
81	$6\frac{3}{4}$	$1.483 \times 10^{-3}$	$6.744 \times 10^2$
39	$6\frac{7}{8}$	$7.274 \times 10^{-4}$	$1.375 \times 10^3$
41	$6\frac{7}{8}$	$7.647 \times 10^{-4}$	$1.308 \times 10^3$
59	$6\frac{7}{8}$	$1.101 \times 10^{-3}$	$9.086 \times 10^2$
60	$6\frac{7}{8}$	$1.119 \times 10^{-3}$	$8.935 \times 10^2$
61	$6\frac{7}{8}$	$1.138 \times 10^{-3}$	$8.790 \times 10^2$
80	$6\frac{7}{8}$	$1.492 \times 10^{-3}$	$6.702 \times 10^2$
81	$6\frac{7}{8}$	$1.511 \times 10^{-3}$	$6.619 \times 10^2$

TABLE XXII.—*Continued.*

$d$	$\pi R$	$k_{gd}$	$1/k_{gd}$
39	7	$7.406 \times 10^{-4}$	$1.350 \times 10^3$
41	7	$7.785 \times 10^{-4}$	$1.284 \times 10^3$
59	7	$1.120 \times 10^{-3}$	$8.925 \times 10^2$
60	7	$1.140 \times 10^{-3}$	$8.776 \times 10^2$
61	7	$1.158 \times 10^{-3}$	$8.634 \times 10^2$
80	7	$1.519 \times 10^{-3}$	$6.583 \times 10^2$
81	7	$1.538 \times 10^{-3}$	$6.501 \times 10^2$
39	8	$8.465 \times 10^{-4}$	$1.181 \times 10^3$
41	8	$8.898 \times 10^{-4}$	$1.124 \times 10^3$
59	8	$1.280 \times 10^{-3}$	$7.809 \times 10^2$
60	8	$1.302 \times 10^{-3}$	$7.679 \times 10^2$
61	8	$1.323 \times 10^{-3}$	$7.554 \times 10^2$
80	8	$1.736 \times 10^{-3}$	$5.759 \times 10^2$
81	8	$1.758 \times 10^{-3}$	$5.689 \times 10^2$
39	$8\frac{1}{8}$	$8.598 \times 10^{-4}$	$1.163 \times 10^3$
41	$8\frac{1}{8}$	$9.038 \times 10^{-4}$	$1.106 \times 10^3$
59	$8\frac{1}{8}$	$1.301 \times 10^{-3}$	$7.688 \times 10^2$
60	$8\frac{1}{8}$	$1.323 \times 10^{-3}$	$7.560 \times 10^2$
61	$8\frac{1}{8}$	$1.345 \times 10^{-3}$	$7.437 \times 10^2$
80	$8\frac{1}{8}$	$1.764 \times 10^{-3}$	$5.670 \times 10^2$
81	$8\frac{1}{8}$	$1.785 \times 10^{-3}$	$5.601 \times 10^2$
39	$8\frac{1}{4}$	$8.730 \times 10^{-4}$	$1.146 \times 10^3$
41	$8\frac{1}{4}$	$9.177 \times 10^{-4}$	$1.090 \times 10^3$
59	$8\frac{1}{4}$	$1.320 \times 10^{-3}$	$7.571 \times 10^2$
60	$8\frac{1}{4}$	$1.343 \times 10^{-3}$	$7.446 \times 10^2$
61	$8\frac{1}{4}$	$1.366 \times 10^{-3}$	$7.324 \times 10^2$
80	$8\frac{1}{4}$	$1.791 \times 10^{-3}$	$5.584 \times 10^2$
81	$8\frac{1}{4}$	$1.813 \times 10^{-3}$	$5.516 \times 10^2$

TABLE XXII.—*Continued.*

$d$	$\pi R$	$k_{a,l}$	$1/k_{ad}$
39	$8\frac{3}{8}$	$8.865 \times 10^{-4}$	$1.128 \times 10^3$
41	$8\frac{3}{8}$	$9.311 \times 10^{-4}$	$1.074 \times 10^3$
59	$8\frac{3}{8}$	$1.341 \times 10^{-3}$	$7.459 \times 10^2$
60	$8\frac{3}{8}$	$1.363 \times 10^{-3}$	$7.332 \times 10^2$
61	$8\frac{3}{8}$	$1.386 \times 10^{-3}$	$7.216 \times 10^2$
80	$8\frac{3}{8}$	$1.818 \times 10^{-3}$	$5.501 \times 10^2$
81	$8\frac{3}{8}$	$1.841 \times 10^{-3}$	$5.434 \times 10^2$
39	$8\frac{1}{2}$	$8.993 \times 10^{-4}$	$1.112 \times 10^3$
41	$8\frac{1}{2}$	$9.452 \times 10^{-4}$	$1.058 \times 10^3$
59	$8\frac{1}{2}$	$1.360 \times 10^{-3}$	$7.350 \times 10^2$
60	$8\frac{1}{2}$	$1.384 \times 10^{-3}$	$7.228 \times 10^2$
61	$8\frac{1}{2}$	$1.406 \times 10^{-3}$	$7.111 \times 10^2$
80	$8\frac{1}{2}$	$1.845 \times 10^{-3}$	$5.421 \times 10^2$
81	$8\frac{1}{2}$	$1.867 \times 10^{-3}$	$5.355 \times 10^2$
39	$8\frac{5}{8}$	$9.126 \times 10^{-4}$	$1.096 \times 10^3$
41	$8\frac{5}{8}$	$9.597 \times 10^{-4}$	$1.042 \times 10^3$
59	$8\frac{5}{8}$	$1.380 \times 10^{-3}$	$7.243 \times 10^2$
60	$8\frac{5}{8}$	$1.404 \times 10^{-3}$	$7.122 \times 10^2$
61	$8\frac{5}{8}$	$1.428 \times 10^{-3}$	$7.006 \times 10^2$
80	$8\frac{5}{8}$	$1.872 \times 10^{-3}$	$5.342 \times 10^2$
81	$8\frac{5}{8}$	$1.895 \times 10^{-3}$	$5.276 \times 10^2$
39	$8\frac{3}{4}$	$9.258 \times 10^{-4}$	$1.080 \times 10^3$
41	$8\frac{3}{4}$	$9.728 \times 10^{-4}$	$1.028 \times 10^3$
59	$8\frac{3}{4}$	$1.401 \times 10^{-3}$	$7.141 \times 10^2$
60	$8\frac{3}{4}$	$1.424 \times 10^{-3}$	$7.021 \times 10^2$
61	$8\frac{3}{4}$	$1.447 \times 10^{-3}$	$6.907 \times 10^2$
80	$8\frac{3}{4}$	$1.899 \times 10^{-3}$	$5.266 \times 10^2$
81	$8\frac{3}{4}$	$1.923 \times 10^{-3}$	$5.200 \times 10^2$

TABLE XXII.—*Continued.*

$d$	$\pi R$	$k_{ed}$	$1/k_{ed}$
39	$8\frac{7}{8}$	$9.590 \times 10^{-4}$	$1.065 \times 10^3$
41	$8\frac{7}{8}$	$9.862 \times 10^{-4}$	$1.014 \times 10^3$
59	$8\frac{7}{8}$	$1.420 \times 10^{-3}$	$7.041 \times 10^2$
60	$8\frac{7}{8}$	$1.444 \times 10^{-3}$	$6.923 \times 10^2$
61	$8\frac{7}{8}$	$1.469 \times 10^{-3}$	$6.811 \times 10^2$
80	$8\frac{7}{8}$	$1.926 \times 10^{-3}$	$5.193 \times 10^2$
81	$8\frac{7}{8}$	$1.950 \times 10^{-3}$	$5.129 \times 10^2$
39	9	$9.521 \times 10^{-4}$	$1.051 \times 10^3$
41	9	$1.001 \times 10^{-3}$	$9.991 \times 10^2$
59	9	$1.144 \times 10^{-3}$	$8.740 \times 10^2$
60	9	$1.465 \times 10^{-3}$	$6.826 \times 10^2$
61	9	$1.489 \times 10^{-3}$	$6.716 \times 10^2$
80	9	$1.953 \times 10^{-3}$	$5.121 \times 10^2$
81	9	$1.977 \times 10^{-3}$	$5.058 \times 10^2$
39	$9\frac{1}{8}$	$9.654 \times 10^{-4}$	$1.036 \times 10^3$
41	$9\frac{1}{8}$	$1.015 \times 10^{-3}$	$9.854 \times 10^2$
59	$9\frac{1}{8}$	$1.461 \times 10^{-3}$	$6.847 \times 10^2$
60	$9\frac{1}{8}$	$1.486 \times 10^{-3}$	$6.733 \times 10^2$
61	$9\frac{1}{8}$	$1.510 \times 10^{-3}$	$6.624 \times 10^2$
80	$9\frac{1}{8}$	$1.980 \times 10^{-3}$	$5.051 \times 10^2$
81	$9\frac{1}{8}$	$2.004 \times 10^{-3}$	$4.987 \times 10^2$
39	$9\frac{1}{4}$	$9.786 \times 10^{-4}$	$1.022 \times 10^3$
41	$9\frac{1}{4}$	$1.029 \times 10^{-3}$	$9.721 \times 10^2$
59	$9\frac{1}{4}$	$1.480 \times 10^{-3}$	$6.754 \times 10^2$
60	$9\frac{1}{4}$	$1.505 \times 10^{-3}$	$6.642 \times 10^2$
61	$9\frac{1}{4}$	$1.531 \times 10^{-3}$	$6.534 \times 10^2$
80	$9\frac{1}{4}$	$2.007 \times 10^{-3}$	$4.982 \times 10^2$
81	$9\frac{1}{4}$	$2.032 \times 10^{-3}$	$4.920 \times 10^2$

TABLE XXII.—*Continued.*

$d$	$\pi R$	$k_{cd}$	$1/k_{cd}$
39	$9\frac{3}{8}$	$9.917 \times 10^{-4}$	$1.008 \times 10^3$
41	$9\frac{3}{8}$	$1.042 \times 10^{-3}$	$9.952 \times 10^2$
59	$9\frac{3}{8}$	$1.501 \times 10^{-3}$	$6.665 \times 10^2$
60	$9\frac{3}{8}$	$1.526 \times 10^{-3}$	$6.564 \times 10^2$
61	$9\frac{3}{8}$	$1.551 \times 10^{-3}$	$6.448 \times 10^2$
80	$9\frac{3}{8}$	$2.034 \times 10^{-3}$	$4.916 \times 10^2$
81	$9\frac{3}{8}$	$2.060 \times 10^{-3}$	$4.855 \times 10^2$
39	$9\frac{1}{2}$	$1.005 \times 10^{-3}$	$9.949 \times 10^2$
41	$9\frac{1}{2}$	$1.056 \times 10^{-3}$	$9.464 \times 10^2$
59	$9\frac{1}{2}$	$1.521 \times 10^{-3}$	$6.577 \times 10^2$
60	$9\frac{1}{2}$	$1.546 \times 10^{-3}$	$6.468 \times 10^2$
61	$9\frac{1}{2}$	$1.571 \times 10^{-3}$	$6.362 \times 10^2$
80	$9\frac{1}{2}$	$2.062 \times 10^{-3}$	$4.851 \times 10^2$
81	$9\frac{1}{2}$	$2.087 \times 10^{-3}$	$4.790 \times 10^2$

## WORKED EXAMPLES.

143.—1. **A Can Gill Box** the F.R. of which has a *working* circumference,

$$\pi R = 6\frac{7}{8} \text{ inches.}$$

The stop wheel " $d$ " = 39 teeth.

The K.O. change wheel  $b = K = 62$  teeth.

Nett weight of sliver in can =  $27\frac{1}{2}$  lbs.

Find weight of sliver  $w$  drams per  $l = 80$  yards.

Substituting in (109),

$$\text{Where} \quad w = \frac{1}{k_{cd}} \frac{W_a}{K}.$$

$$\text{Then} \quad w = 1.375 \times 10^3 \times 27.5/62.$$

$$\text{Hence} \quad w = 609.8 \text{ drams. } \textit{Ans.}$$

2. **A Spindle Gill Box** having the following dimensions:—  
 $\pi R = 6\frac{3}{8}$  inches ;  $d = 60$  ; and  $W_a = 17$ . (*Note.*— $s = 2$ .)  
 Find value of  $K$ .

Substituting in (108),

$$\text{Where} \quad K = \frac{1}{k_{ad}} \frac{W_a}{w}.$$

$$\text{Then} \quad K = 9.638 \times 10^2 \times 17/380.$$

$$\text{Hence} \quad K = 43 \text{ teeth. } \textit{Ans.}$$

3. **A Can Gill Box** the value of  $\pi R = 7$  ;  $d = 59$  ;  $K = 27$  ;  
 and  $w = 560$ . Find  $W_g$ .

Substituting in (107),

$$\text{Where} \quad W_a = k_{ad} K w.$$

$$\text{Then} \quad W_a = 1.120 \times 10^{-3} \times 27 \times 560.$$

$$\text{Hence} \quad W_g = 16.93 \text{ lbs. } \textit{Ans.}$$

144. **For the drawing and roving boxes, both cone and open, the weight per bobbin** is more convenient for the formulæ which will be derived.

In general formula (73),

$$\text{Where} \quad W = \frac{\pi R}{36} \frac{n_r s t}{256} \frac{w}{l}.$$

Let  $W_b$  = weight in lbs. per *bobbin* of any capacity.

On p. 52, *Table XII.*, column 9, gives the various values of  $N_r$ , which values are those found in actual practice.

$$\text{By (20) } t = d K / n_r. \quad \therefore n_r t = d K. \quad (110)$$

Substituting in (73)

$$d K = n_r t, s = 1, \text{ and } l = 80.$$

$$\text{Then} \quad W_b = \frac{\pi R}{36} \frac{d K}{256} \frac{1}{80} \quad (111)$$



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Then  $W_b = 4.262 \times 10^{-6} R d K w.$  . . . (112)

Let  $k_b = 4.262 \times 10^{-6} R.$  . . . (113)

Then  $W_b = k_b d K w.$  . . . (114)

Transposing in (114).

Then  $K = \frac{1}{k_b} \frac{1}{d} \frac{W_b}{w}.$  . . . (115)

Then  $w = \frac{1}{k_b} \frac{1}{d} \frac{W_b}{K}.$  . . . (116)

## SECTION 145.

## TABLE XXIII.

R	$k_b$	$1/k_b$
1	$4.262 \times 10^{-6}$	$2.346 \times 10^5$
2	$8.523 \times 10^{-6}$	$1.173 \times 10^5$
2.5	$1.065 \times 10^{-5}$	$9.380 \times 10^4$
3	$1.278 \times 10^{-5}$	$7.819 \times 10^4$
3.5	$1.491 \times 10^{-5}$	$6.704 \times 10^4$
4	$1.705 \times 10^{-5}$	$5.865 \times 10^4$
4.5	$1.918 \times 10^{-5}$	$5.214 \times 10^4$
5	$2.131 \times 10^{-5}$	$4.692 \times 10^4$

146. Let  $k_{bd} = k_b d.$  (Note.— $d$  = driven peg wheel.)

Then  $W_b = k_{bd} K w.$  . . . (117)

By transposition in (117).

Then  $K = \frac{1}{k_{bd}} \frac{W_b}{w}.$  . . . (118)

Then  $w = \frac{1}{k_{bd}} \frac{W_b}{K}.$  . . . (119)

## SECTION 147.

## TABLE XXIV.

$d$	$R$	$k_{vel}$	$1/k_{vel}$
39	2	$3.324 \times 10^{-4}$	$3.008 \times 10^3$
41	2	$3.494 \times 10^{-4}$	$2.862 \times 10^3$
59	2	$5.029 \times 10^{-4}$	$1.988 \times 10^3$
60	2	$5.114 \times 10^{-4}$	$1.955 \times 10^3$
61	2	$5.198 \times 10^{-4}$	$1.923 \times 10^3$
80	2	$6.819 \times 10^{-4}$	$1.467 \times 10^3$
81	2	$6.904 \times 10^{-4}$	$1.448 \times 10^3$
39	2.5	$4.156 \times 10^{-4}$	$2.406 \times 10^3$
41	2.5	$4.368 \times 10^{-4}$	$2.290 \times 10^3$
59	2.5	$6.287 \times 10^{-4}$	$1.591 \times 10^3$
60	2.5	$6.393 \times 10^{-4}$	$1.564 \times 10^3$
61	2.5	$6.498 \times 10^{-4}$	$1.539 \times 10^3$
80	2.5	$8.523 \times 10^{-4}$	$1.173 \times 10^3$
81	2.5	$8.630 \times 10^{-4}$	$1.159 \times 10^3$
39	3	$4.986 \times 10^{-4}$	$2.005 \times 10^3$
41	3	$5.242 \times 10^{-4}$	$1.907 \times 10^3$
59	3	$7.544 \times 10^{-4}$	$1.325 \times 10^3$
60	3	$7.672 \times 10^{-4}$	$1.303 \times 10^3$
61	3	$7.798 \times 10^{-4}$	$1.282 \times 10^3$
80	3	$1.021 \times 10^{-3}$	$9.779 \times 10^2$
81	3	$1.035 \times 10^{-3}$	$9.656 \times 10^2$
39	3.5	$5.819 \times 10^{-4}$	$1.719 \times 10^3$
41	3.5	$6.116 \times 10^{-4}$	$1.635 \times 10^3$
59	3.5	$8.802 \times 10^{-4}$	$1.136 \times 10^3$
60	3.5	$8.952 \times 10^{-4}$	$1.117 \times 10^3$
61	3.5	$9.099 \times 10^{-4}$	$1.099 \times 10^3$
80	3.5	$1.193 \times 10^{-3}$	$8.379 \times 10^2$
81	3.5	$1.209 \times 10^{-3}$	$8.275 \times 10^2$

TABLE XXIV.—*Continued.*

$d$	R	$k_{bd}$	$1/k_{bd}$
39	4	$6.649 \times 10^{-4}$	$1.504 \times 10^3$
41	4	$6.990 \times 10^{-4}$	$1.431 \times 10^3$
59	4	$1.006 \times 10^{-3}$	$9.940 \times 10^2$
60	4	$1.023 \times 10^{-3}$	$9.774 \times 10^2$
61	4	$1.040 \times 10^{-3}$	$9.616 \times 10^2$
80	4	$1.364 \times 10^{-3}$	$7.331 \times 10^2$
81	4	$1.381 \times 10^{-3}$	$7.241 \times 10^2$
39	4.5	$7.480 \times 10^{-4}$	$1.337 \times 10^3$
41	4.5	$7.863 \times 10^{-4}$	$1.272 \times 10^3$
59	4.5	$1.132 \times 10^{-3}$	$8.837 \times 10^2$
60	4.5	$1.151 \times 10^{-3}$	$8.690 \times 10^2$
61	4.5	$1.169 \times 10^{-3}$	$8.549 \times 10^2$
80	4.5	$1.534 \times 10^{-3}$	$6.518 \times 10^2$
81	4.5	$1.553 \times 10^{-3}$	$6.437 \times 10^2$
39	5	$8.312 \times 10^{-4}$	$1.203 \times 10^3$
41	5	$8.738 \times 10^{-4}$	$1.145 \times 10^3$
59	5	$1.257 \times 10^{-3}$	$7.952 \times 10^2$
60	5	$1.278 \times 10^{-3}$	$7.820 \times 10^2$
61	5	$1.300 \times 10^{-3}$	$7.693 \times 10^2$
80	5	$1.705 \times 10^{-3}$	$5.865 \times 10^2$
81	5	$1.726 \times 10^{-3}$	$5.793 \times 10^2$

## WORKED EXAMPLES.

148.—1. **A Reducing Box** has a 4-inch diameter F.R. driven peg or stop wheel 60 teeth. Find number of teeth in K.O. change wheel in order to run 1.8 lbs. per bobbin, the sliver being 44 drams per 80 yards ?

Substituting in (118),

Where 
$$K = \frac{1}{k_{bd}} \frac{W_b}{w}.$$

Then 
$$K = 9.774 \times 10^2 \times 1.8/44.$$

Hence 
$$K = 40 \text{ teeth. } Ans.$$

2. Find weight of sliver in  $w$  drams per  $l = 80$  yards on a reducing box when  $d = 81$ ;  $K = 52$ ;  $W_b = 1.2$ ; and  $R = 4$ .

Substituting in (119),

Where 
$$w = \frac{1}{k_{bd}} \frac{W_b}{K}.$$

Then 
$$w = 7.241 \times 10^2 \times 1.2/52.$$

Hence 
$$w = 16.71 \text{ drams. } Ans.$$

3. What will be the value of  $W_b$  when  $d = 59$ ;  $R = 3$ ;  $K = 41$ ; and  $w = 21$  drams?

Substituting in (117),

Where 
$$W_b = k_{bd} K w.$$

Then 
$$W_b = 7.544 \times 10^{-4} \times 41 \times 21.$$

Hence 
$$W_b = 0.6495 \text{ lbs. } Ans.$$

**149. To derive comprehensive formulæ for weight in lbs. per bobbin, knock-off change wheel, and weight in drams per 80 yards of sliver on drawing boxes with 5-wheel type of knock-off motion.**

Let  $W_b$  = weight in lbs. per bobbin per doff.

„  $K$  = number of teeth in K.O. change wheel.

(Note.— $e = K$ .)

„  $R$  = diameter in inches of F.R.

„  $N_2$  = total number of revolutions of F.R. per doff.

„  $l$  = length of sliver in yards per  $w$  drams.

„  $w$  = weight of sliver in drams per “ $l$ ” yards.

„  $s$  = number of spindles.

Then 
$$W_b = \frac{\pi R}{36} \frac{s N_a}{256} \frac{w}{l}. \quad . \quad . \quad . \quad (120)$$

But 
$$N_a = \frac{b d f}{a c K}. \quad . \quad . \quad . \quad . \quad . \quad (22)$$

Section 70, p. 52, *Table XII.*, gives the numerical values of  $a$ ,  $b$ ,  $c$ ,  $d$ , and  $f$ .

Substituting (22) in (120).

Then 
$$W_b = \frac{\pi R}{36} \frac{s}{256} \frac{b d f}{a c K} \frac{w}{l}. \quad . \quad . \quad . \quad (121)$$

Substituting in (121)  $s = 1$ ;  $d = 60$ ;  $a = 1$ ;  $c = 1$ ; and  $l = 80$ .

Then 
$$W_b = 1.535 \times 10^{-2} R b w / K. \quad . \quad . \quad (122)$$

Let 
$$k_5 = 1.535 \times 10^{-2} R. \quad . \quad . \quad . \quad (123)$$

Then 
$$W_b = k_5 b w / K. \quad . \quad . \quad . \quad . \quad (124)$$

By transposition in (124).

Then 
$$K = k_5 b w / W_b. \quad . \quad . \quad . \quad . \quad (125)$$

And 
$$w = \frac{1}{k_5} \frac{1}{b} K W_b. \quad . \quad . \quad . \quad (126)$$

## SECTION 150.

## TABLE XXV.

R	$k_5$	$1/k_5$
2	$3.069 \times 10^{-2}$	$3.258 \times 10^1$
2.5	$3.836 \times 10^{-2}$	$2.607 \times 10^1$
3	$4.604 \times 10^{-2}$	$2.172 \times 10^1$
3.5	$5.371 \times 10^{-2}$	$1.862 \times 10^1$
4	$6.139 \times 10^{-2}$	$1.629 \times 10^1$
4.5	$6.905 \times 10^{-2}$	$1.448 \times 10^1$
5	$7.674 \times 10^{-2}$	$1.303 \times 10^1$

$$151.4 \quad \text{Let } k_5 b = k_{5b}. \quad (127)$$

(Note.— $b$  = spur worn wheel.)

$$\text{Then } W_b = k_{5b} w/K. \quad (128)$$

$$\text{Then } K = k_{5b} w/W_b. \quad (129)$$

$$\text{And } w = \frac{1}{k_{5b}} K W_b. \quad (130)$$

## SECTION 152.

## TABLE XXVI.

$b$	R	$k_{5b}$	$1/k_{5b}$
17	2	$5.213 \times 10^{-1}$	$1.917 \times 10^0$
19	2	$5.832 \times 10^{-1}$	$1.715 \times 10^0$
21	2	$6.445 \times 10^{-1}$	$1.552 \times 10^0$
22	2	$6.751 \times 10^{-1}$	$1.481 \times 10^0$
23	2	$7.058 \times 10^{-1}$	$1.417 \times 10^0$
24	2	$7.537 \times 10^{-1}$	$1.358 \times 10^0$
17	2.5	$6.521 \times 10^{-1}$	$1.533 \times 10^0$
19	2.5	$7.290 \times 10^{-1}$	$1.372 \times 10^0$
21	2.5	$8.056 \times 10^{-1}$	$1.242 \times 10^0$
22	2.5	$8.439 \times 10^{-1}$	$1.185 \times 10^0$
23	2.5	$8.822 \times 10^{-1}$	$1.133 \times 10^0$
24	2.5	$9.206 \times 10^{-1}$	$1.086 \times 10^0$
17	3	$7.825 \times 10^{-1}$	$1.277 \times 10^0$
19	3	$8.748 \times 10^{-1}$	$1.143 \times 10^0$
21	3	$9.668 \times 10^{-1}$	$1.035 \times 10^0$
22	3	$1.013 \times 10^0$	$9.874 \times 10^{-1}$
23	3	$1.059 \times 10^0$	$9.445 \times 10^{-1}$
24	3	$1.105 \times 10^0$	$9.051 \times 10^{-1}$
17	3.5	$9.131 \times 10^{-1}$	$1.095 \times 10^0$
19	3.5	$1.021 \times 10^0$	$9.797 \times 10^{-1}$
21	3.5	$1.128 \times 10^0$	$8.865 \times 10^{-1}$
22	3.5	$1.181 \times 10^0$	$8.463 \times 10^{-1}$
23	3.5	$1.235 \times 10^0$	$8.095 \times 10^{-1}$
24	3.5	$1.289 \times 10^0$	$7.757 \times 10^{-1}$

TABLE XXVI.—*Continued.*

$b$	$R$	$k_{3b}$	$1/k_{3b}$
17	4	$1.043 \times 10^0$	$9.583 \times 10^{-1}$
19	4	$1.166 \times 10^0$	$8.572 \times 10^{-1}$
21	4	$1.289 \times 10^0$	$7.757 \times 10^{-1}$
22	4	$1.351 \times 10^0$	$7.402 \times 10^{-1}$
23	4	$1.412 \times 10^0$	$7.082 \times 10^{-1}$
24	4	$1.473 \times 10^0$	$6.787 \times 10^{-1}$
17	4.5	$1.174 \times 10^0$	$8.519 \times 10^{-1}$
19	4.5	$1.312 \times 10^0$	$7.621 \times 10^{-1}$
21	4.5	$1.450 \times 10^0$	$6.896 \times 10^{-1}$
22	4.5	$1.519 \times 10^0$	$6.583 \times 10^{-1}$
23	4.5	$1.588 \times 10^0$	$6.296 \times 10^{-1}$
24	4.5	$1.658 \times 10^0$	$6.034 \times 10^{-1}$
17	5	$1.304 \times 10^0$	$7.667 \times 10^{-1}$
19	5	$1.458 \times 10^0$	$6.858 \times 10^{-1}$
21	5	$1.611 \times 10^0$	$6.205 \times 10^{-1}$
22	5	$1.689 \times 10^0$	$5.924 \times 10^{-1}$
23	5	$1.765 \times 10^0$	$5.666 \times 10^{-1}$
24	5	$1.842 \times 10^0$	$5.430 \times 10^{-1}$

## WORKED EXAMPLES.

153.—1. **A weigh box**, the front roller of which is 4 inches in diameter, and a knock-off train of wheels of the 5-wheel type being  $a = 1$ ,  $b = 17$ ,  $c = 1$ ,  $d = 60$ , and  $f = 60$ , delivering a sliver of 220 drams for 80 yards. It is required to find the knock-off change wheel in order to place wool on a bobbin, the capacity of which is 5 pounds.

*Solution.*

*Note.*—Pp. 50 and 51, Sections 67 and 68.

$R = 4$ ,  $W_b = 5$ , and  $e = K =$  the unknown value.

By substituting in (129), (Note.— $k_{bb} = 1.043 \times 10^\circ$ ,  
Table XXVI.)

Where  $K = k_{bb} w / W_b$ .

Then  $K = 1.043 \times 10^\circ \times 220/5$ ,

$\therefore K = 46$ . *Ans.*

2. **A finishing box** with a 3-inch diameter front roller, ordinary 5-wheel type of knock-off motion ( $17 \times 60 \times 60$ ), bobbin capacity  $4\frac{1}{2}$  lbs. of wool, and K.O. change wheel 37 teeth knocking off *twice* per doff. Find weight of sliver in drams for 40 yards.

Now  $R = 3$ ,  $W_b = 4\frac{1}{2}$ , and  $K_s = 37/2$ .

By substituting in (130), (Note.—For  $1/k_{bb}$ , see  
Table XXVI.)

Where  $w = 1/k_{bb} K W_b$ .

Then  $w = 1.277 \times 10^\circ \times \frac{37}{2} \times 4\frac{1}{2}$ .

$\therefore w = 106.3$  drams when  $l = 80$ .

$\therefore w = 53.15$  „ „  $l = 40$ .

$\therefore w = 53.15$  drams. *Ans.*

3. **An eight spindle first finishing-box** has the following known particulars :—

$R = 4$ ,  $w = 160$ , and  $K = 24$  (ordinary 5-wheel type).

Find value of  $W_b$ .

By substituting in (128),

Where  $W_b = k_{bb} w / K$ .

Then  $W_b = 1.043 \times 10^\circ \times 160/24$ .

$\therefore W_b = 7$  (approx.). *Ans.*



154.—To find  $W$ , rate of production in lbs. per hour in terms of  $W_d$ , weight per doff in lbs., so as to make a two-fold use of Table XX., Section 137, pp. 102 to 108.

$$\text{Now} \quad W = \frac{\pi R}{36} \frac{n_s s t}{560} \frac{1}{H}, \quad . \quad . \quad . \quad (67)$$

$$\text{and} \quad W_d = \frac{\pi R}{36} \frac{s}{560} \frac{N_s}{H}, \quad . \quad . \quad . \quad (84)$$

$$\text{Let} \quad h_s = \frac{\pi R}{36} \frac{s}{560} \frac{60}{1}.$$

$$\text{Then} \quad W = h_s n_s / H, \quad . \quad . \quad . \quad . \quad (82)$$

$$\text{and} \quad W_d = h_s 2 K / H, \quad . \quad . \quad . \quad . \quad (131)$$

$$\text{But} \quad W_d = h_{ds} K / H, \quad . \quad . \quad . \quad . \quad (90)$$

$$\text{Hence} \quad \frac{h_s n_s}{H} = \frac{h_s 2 K}{H} = \frac{h_{ds} K}{H}.$$

$$\text{Then} \quad 2 h_s = h_{ds}, \quad . \quad . \quad . \quad . \quad . \quad (132)$$

$$\therefore \quad h_s = h_{ds} / 2 \text{ (see Section 133).} \quad (132.1)$$

$$\text{Now} \quad W = h_s n_s / H \quad . \quad . \quad . \quad . \quad (82)$$

$$\text{and} \quad W = 6.135 n_s / H, \quad . \quad . \quad . \quad . \quad (83)$$

$$\text{Hence} \quad h_s = 6.135 \text{ when } R = 4 \text{ and } s = 164.$$

(Note.—See Section 133, p. 99).

$$\text{But} \quad h_s = h_{ds} / 2, \quad . \quad . \quad . \quad . \quad . \quad (132.1)$$

(Note.—For  $h_{ds}$  see Table XX, p. 106).

$$\text{Then} \quad h_s = 12.27 / 2.$$

$$\therefore \quad h_s = 6.135 \text{ constant in.} \quad . \quad . \quad . \quad (83)$$



# 130 WORSTED DRAWING AND SPINNING CALCULATIONS.

Also, further note the following tabulated properties in Table :—

TABLE XXVIII.

SECTION 157.

Proportion :—Hank.			1/560.	p/256.
1	$\frac{2}{28}$	$\frac{1}{14}$	$\frac{40}{560}$	$\frac{18\cdot29}{256}$
2	$\frac{4}{28}$	$\frac{1}{7}$	$\frac{80}{560}$	$\frac{36\cdot57}{256}$
3	$\frac{6}{28}$	$\frac{3}{14}$	$\frac{120}{560}$	$\frac{54\cdot86}{256}$
3·5	$\frac{7}{28}$	$\frac{1}{4}$	$\frac{140}{560}$	$\frac{64\cdot00}{256}$

158.—It will be seen that  $l$  is to 560 yards (standard length) as  $p$  is to 256 drams (standard weight)—*e.g.*,

$$\text{As } l : 560 :: p : 256.$$

$$\text{Hence } \frac{l}{560} = \frac{p}{256}.$$

$$\text{Then } 256 l = 560 p.$$

$$\therefore l = \frac{560}{256} p.$$

$$\therefore l = 2\cdot188 p. \quad . \quad . \quad . \quad (45\cdot1)$$

and 
$$p = \frac{256}{560} l.$$

$$p = 0.4571 l. \quad . \quad . \quad . \quad (44.1)$$

159. Table XXIX. gives the *numerical values* of H (hanks) or C (counts) when H *equals* C in **millihanks** and **millidrams**. See Sections 14, 103, 107, and 108, pp. 7, 75, 76, 79, and 80.

The numbers are in the *abstract*, hence a *two-fold* use may be made if named, and made *concrete*.

160. *Examples*.—1. A sliver is 104 drams for 40 yards, it is required to find the *count*?

*Solution*.—Find 104 in Column I.

*Answer*.—175.8 millihanks in Column II. or 0.1758 hank or count.

2. If count of a sliver is 0.1758, what is the weight in drams of 40, 80, 120, and 140 yards?

*Solution*.—Find 176 in Column I.

*Answer*.—The weights are 104, 208, 312, and 364 drams in Columns II., III., IV., and V.

## SECTION 161. TABLE XXIX.

I. No.	II. 40	III. 80	IV. 120	V. 140
1	18,286	36,572	54,858	64,000
2	9,143	18,286	27,429	32,000
3	6,095	12,190	18,285	21,333
4	4,571	9,142	13,713	16,000
5	3,657	7,314	10,971	12,800
6	3,047	6,094	9,141	10,667
7	2,612	5,224	7,836	9,143
8	2,286	4,572	6,858	8,000
9	2,032	4,064	6,096	7,111
10	1,829	3,657	5,484	6,400
11	1,663	3,326	4,989	5,819
12	1,524	3,048	4,572	5,333
13	1,407	2,814	4,221	4,923
14	1,306	2,612	3,918	4,571
15	1,219	2,438	3,657	4,267
16	1,143	2,286	3,429	4,000
17	1,076	2,152	3,228	3,765
18	1,016	2,032	3,048	3,556
19	962·3	1,924·6	2,886·9	3,368
20	914·3	1,828·6	2,742·9	3,200
21	870·8	1,741·6	2,012·4	3,048
22	831·2	1,662·4	2,493·6	2,909
23	795·0	1,590·0	2,385·0	2,783
24	761·9	1,523·8	2,285·7	2,667
25	731·4	1,462·8	2,194·2	2,560
26	703·3	1,406·6	2,109·9	2,461
27	677·2	1,354·4	2,031·6	2,370
28	653·0	1,306·0	1,959·0	2,286
29	630·5	1,261·0	1,891·5	2,207
30	609·5	1,219·0	1,827·5	2,133
31	589·8	1,179·6	1,769·4	2,065
32	571·5	1,143·0	1,714·5	2,000
33	554·2	1,108·4	1,662·6	1,939

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
34	537·8	1,075·6	1,613·4	1,882
35	522·4	1,044·8	1,567·2	1,828
36	507·9	1,015·8	1,523·7	1,778
37	494·2	988·4	1,482·6	1,730
38	481·1	962·2	1,443·3	1,684
39	468·8	937·6	1,406·4	1,641
40	457·1	914·2	1,371·3	1,600
41	446·0	892·0	1,338·0	1,561
42	435·4	870·8	1,306·2	1,524
43	425·2	850·4	1,275·6	1,488
44	415·6	831·2	1,246·8	1,454
45	406·3	812·6	1,218·9	1,422
46	397·5	795·0	1,192·5	1,391
47	389·0	778·0	1,167·0	1,361
48	381·0	762·0	1,143·0	1,334
49	373·2	746·4	1,119·6	1,306
50	365·7	731·4	1,097·1	1,280
51	358·5	717·0	1,075·5	1,255
52	351·7	703·4	1,055·1	1,231
53	344·9	689·8	1,034·7	1,207
54	338·6	677·2	1,015·8	1,185
55	332·4	664·8	997·2	1,163
56	326·5	653·0	979·5	1,143
57	320·7	641·4	962·1	1,122
58	315·3	630·6	945·9	1,104
59	309·8	619·6	929·4	1,084
60	304·7	609·4	914·1	1,067
61	299·7	599·4	899·1	1,049
62	294·9	589·8	884·7	1,032
63	290·2	580·4	870·6	1,016
64	285·7	571·4	857·1	1,000
65	281·3	562·6	843·9	984·6
66	277·1	554·2	831·3	969·9

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
67	272.9	545.8	818.7	955.2
68	268.9	537.8	806.7	941.2
69	265.1	530.2	795.3	927.9
70	261.2	522.4	783.6	914.2
71	257.5	515.0	772.5	901.3
72	254.0	508.0	762.0	889.0
73	250.5	501.0	751.5	876.8
74	247.1	494.2	741.3	864.9
75	243.8	487.6	731.4	853.3
76	240.6	481.2	721.8	842.1
77	237.4	474.8	712.2	831.2
78	234.4	468.8	703.2	820.5
79	231.5	463.0	694.5	810.2
80	228.6	457.2	685.8	800.0
81	225.7	451.4	677.1	790.1
82	223.0	446.0	669.0	780.5
83	220.3	440.6	660.9	771.1
84	217.7	435.4	653.1	761.9
85	215.1	430.2	645.3	753.0
86	212.6	425.2	637.8	744.1
87	210.2	420.4	630.6	735.7
88	207.8	415.6	623.4	727.3
89	205.4	410.8	616.2	719.1
90	203.2	406.4	609.6	711.2
91	200.9	401.8	602.7	703.2
92	198.7	397.4	596.1	695.6
93	196.6	393.2	589.8	668.1
94	194.5	384.5	583.5	680.9
95	192.5	385.0	577.5	673.8
96	190.4	380.8	571.2	666.6
97	188.5	377.0	565.5	659.8
98	186.6	373.2	559.8	653.1
99	184.7	369.4	554.1	646.6

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
100	182.8	365.6	548.4	640.0
101	181.0	362.0	543.0	633.7
102	179.3	358.6	537.9	627.5
103	177.6	355.2	532.8	621.5
104	175.8	351.6	527.4	615.5
105	174.2	348.4	522.6	609.5
106	172.5	345.0	517.5	603.9
107	170.9	341.8	512.7	598.1
108	169.3	338.6	507.9	592.7
109	167.8	335.6	503.4	587.3
110	166.2	332.4	498.6	581.8
111	164.7	329.4	494.1	576.6
112	163.2	326.4	489.6	571.4
113	161.8	323.6	485.4	566.3
114	160.4	320.8	481.2	561.4
115	159.0	318.0	477.0	556.5
116	157.6	315.2	472.8	551.7
117	156.3	312.6	468.9	547.0
118	155.0	310.0	465.0	542.5
119	153.7	307.4	461.1	537.9
120	152.4	304.8	457.2	533.3
121	151.1	302.2	453.3	528.9
122	149.9	299.8	449.7	524.6
123	148.7	297.4	446.1	520.4
124	147.5	295.0	442.5	516.2
125	146.3	292.6	438.9	512.1
126	145.1	290.2	435.3	507.9
127	144.0	288.0	432.0	504.0
128	142.9	285.8	428.7	500.0
129	141.8	283.6	425.4	496.2
130	140.7	281.4	422.1	492.3
131	139.6	279.2	418.8	488.5
132	138.6	277.2	415.8	485.2



TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
133	137.5	275.0	412.5	481.2
134	136.5	273.0	409.5	477.7
135	135.5	271.0	406.5	474.2
136	134.5	269.0	403.5	470.7
137	133.5	267.0	400.5	467.2
138	132.5	265.0	397.5	463.7
139	131.6	263.2	394.8	460.5
140	130.6	261.2	391.8	457.1
141	129.7	259.4	389.1	453.9
142	128.7	257.4	386.1	450.7
143	127.9	255.8	383.7	447.6
144	127.0	254.0	381.0	444.4
145	126.1	252.2	378.3	441.4
146	125.2	250.4	375.6	438.3
147	124.1	248.2	372.3	434.4
148	123.5	247.0	370.5	432.4
149	122.7	245.4	368.1	429.5
150	121.9	243.8	365.7	426.6
151	121.1	242.2	363.3	423.8
152	120.3	240.6	360.9	421.5
153	119.5	239.0	358.5	418.3
154	118.8	237.6	356.4	415.7
155	118.0	236.0	354.0	413.0
156	117.2	234.4	351.6	410.3
157	116.5	233.0	349.5	407.7
158	115.7	231.4	347.1	405.1
159	115.0	230.0	345.0	402.5
160	114.3	228.6	342.9	400.0
161	113.6	227.2	340.8	397.6
162	112.9	225.8	338.7	395.1
163	112.1	224.2	336.3	392.6
164	111.5	223.0	334.5	390.3
165	110.8	221.6	332.4	387.8

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
166	110.2	220.4	330.6	385.6
167	109.5	219.0	328.5	383.2
168	108.8	217.6	326.4	381.0
169	108.2	216.4	324.6	378.7
170	107.6	215.2	322.8	376.5
171	106.9	213.8	320.7	374.3
172	106.3	212.6	318.9	372.1
173	105.7	211.4	317.1	370.0
174	105.1	210.2	315.3	367.9
175	104.5	209.0	313.5	365.8
176	103.9	207.8	311.7	363.7
177	103.3	206.6	309.9	361.6
178	102.7	205.4	308.1	359.6
179	102.1	204.2	306.3	357.5
180	101.6	203.2	304.8	355.5
181	101.0	202.0	303.0	353.6
182	100.5	201.0	301.5	351.7
183	99.92	199.8	299.8	349.7
184	99.38	198.8	298.1	347.8
185	98.83	197.7	296.5	345.9
186	98.31	196.6	294.9	344.1
187	97.79	195.6	293.4	342.3
188	97.25	194.5	291.8	340.4
189	96.74	193.5	290.2	338.6
190	96.23	192.5	288.7	336.8
191	95.74	191.5	287.2	335.1
192	95.24	190.5	285.7	333.3
193	94.73	189.5	284.2	331.6
194	94.26	188.5	282.8	329.9
195	93.78	187.6	281.3	328.2
196	93.28	186.6	279.8	326.5
197	92.81	185.6	278.4	324.8
198	92.34	184.7	277.0	323.2

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
199	91·88	183·8	275·6	321·6
200	91·43	182·7	274·3	320·0
201	90·97	181·9	272·9	318·4
202	90·51	181·0	271·5	316·8
203	90·07	181·1	270·2	315·3
204	89·64	179·3	268·9	313·7
205	89·19	178·4	267·6	312·2
206	88·76	177·5	266·3	310·7
207	88·33	176·7	265·0	309·1
208	87·90	175·8	263·7	307·7
209	87·50	175·0	262·5	306·3
210	87·08	174·2	261·2	304·8
211	86·66	173·3	260·0	303·3
212	86·26	172·5	258·8	301·9
213	85·84	171·7	257·5	300·4
214	85·44	170·9	256·3	299·0
215	85·06	170·1	255·2	297·7
216	84·65	169·3	254·0	296·3
217	84·26	168·5	252·8	294·9
218	83·88	167·8	251·6	293·6
219	83·50	167·0	250·5	292·2
220	83·12	166·2	249·4	290·2
221	82·74	165·5	248·2	289·6
222	82·35	164·7	247·1	288·2
223	82·00	164·0	246·0	287·0
224	81·64	163·3	244·9	285·7
225	81·27	162·5	243·8	284·4
226	80·91	161·8	242·7	283·2
227	80·56	161·1	241·7	281·9
228	80·20	160·4	240·6	280·7
229	79·86	159·7	239·6	279·5
230	79·50	159·0	238·5	278·3
231	79·16	158·3	237·5	277·1

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
232	78·81	157·6	236·4	275·8
233	78·48	157·0	235·4	274·7
234	78·14	156·3	234·4	273·5
235	77·80	155·6	233·4	272·3
236	77·49	155·0	232·5	271·2
237	77·16	154·3	231·5	270·1
238	76·83	153·7	230·5	268·9
239	76·50	153·0	229·5	267·8
240	76·19	152·4	228·6	266·7
241	75·88	151·7	227·6	265·6
242	75·56	151·1	226·7	264·4
243	75·25	150·5	225·8	263·4
244	74·94	149·9	224·8	262·3
245	74·63	149·3	223·9	261·2
246	74·33	148·7	223·0	260·2
247	74·03	148·1	222·1	259·1
248	73·72	147·4	221·2	258·0
249	73·43	146·9	220·3	257·0
250	73·14	146·3	219·4	256·0
251	72·85	145·7	218·6	255·0
252	72·56	145·1	217·7	254·0
253	72·28	144·6	216·8	253·0
254	71·99	144·0	216·0	252·0
255	71·71	143·4	215·1	251·0
256	71·44	142·9	214·3	250·0
257	71·15	142·3	213·5	249·0
258	70·87	141·7	212·6	248·0
259	70·60	141·2	211·8	247·1
260	70·33	140·7	211·0	246·1
261	70·06	140·1	210·2	245·2
262	69·79	139·6	209·4	244·3
263	69·52	139·0	208·6	243·3
264	69·26	138·5	207·8	242·4

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
265	69·01	138·0	207·0	241·5
266	68·74	137·5	206·2	240·6
267	68·48	137·0	205·4	239·7
268	68·24	136·0	204·7	238·8
269	67·97	135·9	203·9	237·9
270	67·72	135·4	203·2	237·0
271	67·47	134·9	202·4	236·1
272	67·22	134·4	201·7	235·3
273	66·97	133·9	200·9	234·4
274	66·73	133·5	200·2	233·5
275	66·49	133·0	199·5	232·7
276	66·25	132·5	198·8	231·9
277	66·01	132·0	198·0	231·0
278	65·77	131·5	197·3	230·2
279	65·54	131·1	196·6	229·4
280	65·31	130·6	195·9	228·6
281	65·08	130·2	195·2	227·8
282	64·85	129·7	194·6	227·0
283	64·62	129·2	193·9	226·2
284	64·39	128·8	193·2	225·4
285	64·16	128·3	192·5	224·6
286	63·93	127·9	191·8	223·8
287	63·71	127·4	191·1	223·0
288	63·49	127·0	190·5	222·2
289	63·27	126·5	189·9	221·4
290	63·05	126·1	189·2	220·7
291	62·84	125·7	188·5	219·9
292	62·62	125·2	187·9	219·2
293	62·40	124·8	187·2	218·4
294	62·20	124·4	186·6	217·7
295	61·98	124·0	185·9	216·9
296	61·77	123·5	185·3	216·2
297	61·56	123·1	184·7	215·5

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
298	61.37	122.7	184.1	214.8
299	61.15	122.3	183.5	214.0
300	60.95	121.9	182.9	213.3
301	60.74	121.5	182.2	212.6
302	60.54	121.1	181.6	211.9
303	60.36	120.7	181.1	211.3
304	60.15	120.3	180.5	210.5
305	59.95	119.9	179.9	209.8
306	59.75	119.5	179.3	209.1
307	59.56	119.1	178.7	208.5
308	59.36	118.7	178.1	207.8
309	59.17	118.3	177.5	207.1
310	58.98	118.0	177.0	206.4
311	58.79	117.6	176.4	205.8
312	58.60	117.2	175.8	205.1
313	58.42	116.8	175.3	204.5
314	58.24	116.5	174.7	203.8
315	58.05	116.1	174.2	203.2
316	57.86	115.7	173.6	202.5
317	57.68	115.4	173.0	201.9
318	57.50	115.0	172.5	201.3
319	57.32	114.6	172.0	200.6
320	57.14	114.3	171.4	200.0
321	56.97	113.9	170.9	199.4
322	56.78	113.6	170.3	198.7
323	56.61	113.2	169.8	198.1
324	56.44	112.9	169.3	197.5
325	56.26	112.5	168.8	196.9
326	56.10	112.2	168.3	196.3
327	55.92	111.8	167.8	195.7
328	55.75	111.5	167.3	195.1
329	55.58	111.2	166.7	194.5
330	55.41	110.8	166.2	193.9

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
331	55.25	110.5	165.8	193.4
332	55.08	110.2	165.2	192.8
333	54.94	109.9	164.8	192.3
334	54.75	109.5	164.3	191.6
335	54.59	109.2	163.8	191.0
336	54.43	108.9	163.3	190.5
337	54.26	108.5	162.8	189.9
338	54.11	108.2	162.3	189.4
339	53.94	107.9	161.8	188.8
340	53.78	107.6	161.3	188.2
341	53.62	107.2	160.9	187.7
342	53.47	106.9	160.4	187.1
343	53.31	106.6	159.9	186.6
344	53.15	106.3	159.5	186.0
345	53.01	106.0	159.0	185.5
346	52.84	105.7	158.5	184.9
347	52.70	105.4	158.1	184.5
348	52.54	105.1	157.6	183.9
349	52.40	104.8	157.2	183.4
350	52.24	104.5	156.7	182.8
351	52.10	104.2	156.3	182.4
352	51.95	103.9	155.9	181.8
353	51.80	103.6	155.4	181.3
354	51.65	103.3	155.0	180.8
355	51.51	103.0	154.5	180.3
356	51.37	102.7	154.1	179.8
357	51.22	102.4	153.7	179.3
358	51.07	102.1	153.2	178.7
359	50.93	101.9	152.8	178.3
360	50.79	101.6	152.4	177.8
361	50.65	101.3	152.0	177.3
362	50.52	101.0	151.6	176.8
363	50.37	100.7	151.1	176.3

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
364	50.23	100.5	150.7	175.8
365	50.09	100.2	150.3	175.3
366	49.96	99.92	149.9	174.9
367	49.82	99.64	149.5	174.4
368	49.69	99.38	149.1	173.9
369	49.56	99.12	148.7	173.5
370	49.42	98.84	148.3	173.0
371	49.28	98.56	147.8	172.5
372	49.16	98.32	147.5	172.1
373	49.03	98.06	147.1	171.6
374	48.89	97.78	146.7	171.1
375	48.76	97.52	146.3	170.7
376	48.63	97.26	145.9	170.2
377	48.50	97.00	145.5	169.7
378	48.38	96.76	145.1	169.3
379	48.25	96.50	144.8	168.9
380	48.12	96.24	144.4	168.4
381	47.99	95.98	144.0	168.0
382	47.86	95.72	143.6	167.5
383	47.74	95.48	143.2	167.1
384	47.62	95.24	142.9	166.7
385	47.49	94.98	142.5	166.2
386	47.37	94.74	142.1	165.8
387	47.25	94.50	141.8	165.4
388	47.13	94.26	141.4	165.0
389	47.01	94.02	141.0	164.5
390	46.88	93.76	140.6	164.1
391	46.77	93.54	140.3	163.7
392	46.65	93.30	140.0	163.2
393	46.53	93.06	139.6	162.9
394	46.41	92.82	139.2	162.4
395	46.29	92.58	138.9	162.0
396	46.17	92.34	138.5	161.6



TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
397	46·06	92·12	138·2	161·2
398	45·94	91·88	137·8	160·8
399	45·82	91·64	137·5	160·4
400	45·71	91·44	137·2	160·0
401	45·60	91·20	136·8	159·6
402	45·48	90·96	136·4	159·2
403	45·37	90·74	136·1	158·8
404	45·26	90·52	135·8	158·4
405	45·15	90·30	135·5	158·0
406	45·04	90·08	135·1	157·6
407	44·92	89·84	134·8	157·2
408	44·81	89·62	134·4	156·8
409	44·71	89·42	134·1	156·5
410	44·60	89·20	133·8	156·1
411	44·49	88·98	133·5	155·7
412	44·38	88·76	133·1	155·3
413	44·27	88·54	132·8	155·0
414	44·17	88·34	132·5	154·6
415	44·07	88·14	132·2	154·3
416	43·95	87·90	131·9	153·8
417	43·85	87·70	131·6	153·5
418	43·74	87·48	131·2	153·1
419	43·64	87·28	130·9	152·8
420	43·54	87·08	130·6	152·4
421	43·43	86·86	130·3	152·0
422	43·33	86·66	130·0	151·7
423	43·23	86·46	129·7	151·3
424	43·12	86·24	129·4	151·0
425	43·02	86·04	129·1	150·6
426	42·92	85·84	128·8	150·2
427	42·83	85·66	128·5	149·9
428	42·73	85·46	128·2	149·6
429	42·62	85·24	127·9	149·2

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
430	42.52	85.04	127.6	148.8
431	42.42	84.84	127.3	148.5
432	42.33	84.66	127.0	148.1
433	42.23	84.46	126.7	147.8
434	42.13	84.26	126.4	147.4
435	42.04	84.08	126.1	147.1
436	41.94	83.88	125.8	146.8
437	41.84	83.68	125.5	146.4
438	41.75	83.50	125.3	146.1
439	41.65	83.30	125.0	145.8
440	41.56	83.12	124.7	145.5
441	41.47	82.94	124.4	145.1
442	41.37	82.74	124.1	144.8
443	41.28	82.56	123.8	144.5
444	41.18	82.36	123.5	144.1
445	41.09	82.18	123.3	143.8
446	41.01	82.02	123.0	143.5
447	40.91	81.82	122.7	143.2
448	40.82	81.64	122.5	142.9
449	40.72	81.44	122.2	142.5
450	40.63	81.26	121.9	142.2
451	40.54	81.08	121.6	141.9
452	40.46	80.92	121.4	141.6
453	40.36	80.72	121.1	141.3
454	40.27	80.54	120.8	140.9
455	40.19	80.38	120.6	140.7
456	40.10	80.20	120.3	140.4
457	40.01	80.02	120.0	140.0
458	39.92	79.84	119.8	139.7
459	39.84	79.68	119.5	139.4
460	39.75	79.50	119.3	139.1
461	39.67	79.34	119.0	138.8
462	39.59	79.18	118.8	138.6

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
463	39.50	79.00	118.5	138.2
464	39.41	78.82	118.2	137.9
465	39.31	78.62	117.9	137.6
466	39.23	78.46	117.7	137.3
467	39.15	78.30	117.5	137.0
468	39.07	78.14	117.2	136.7
469	38.98	77.96	116.9	136.4
470	38.90	77.80	116.7	136.2
471	38.83	77.66	116.5	135.9
472	38.75	77.50	116.3	135.6
473	38.66	77.32	116.0	135.3
474	38.58	77.16	115.7	135.0
475	38.50	77.00	115.5	134.8
476	38.41	76.82	115.2	134.4
477	38.32	76.64	115.0	134.1
478	38.25	76.50	114.8	133.9
479	38.18	76.36	114.5	133.6
480	38.10	76.20	114.3	133.4
481	38.02	76.04	114.1	133.1
482	37.94	75.88	113.8	132.8
483	37.86	75.72	113.6	132.5
484	37.79	75.58	113.4	132.3
485	37.70	75.40	113.1	132.0
486	37.62	75.24	112.9	131.7
487	37.55	75.10	112.7	131.4
488	37.47	74.94	112.4	131.1
489	37.40	74.80	112.2	130.9
490	37.32	74.64	112.0	130.6
491	37.24	74.48	111.7	130.3
492	37.16	74.32	111.5	130.1
493	37.10	74.20	111.3	129.8
494	37.01	74.02	111.0	129.5
495	36.94	73.88	110.8	129.3

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
496	36·86	73·72	110·6	129·0
497	36·79	73·58	110·4	128·8
498	36·72	73·44	110·2	128·5
499	36·64	73·28	109·9	128·2
500	36·57	73·14	109·7	128·0
501	36·51	73·02	109·5	127·7
502	36·42	72·84	109·3	127·5
503	36·35	72·70	109·1	127·2
504	36·28	72·56	108·8	127·0
505	36·21	72·42	108·6	126·7
506	36·13	72·26	108·4	126·5
507	36·07	72·14	108·2	126·3
508	35·99	71·98	108·0	126·0
509	35·92	71·84	107·8	125·7
510	35·85	71·70	107·6	125·5
511	35·79	71·58	107·4	125·2
512	35·72	71·44	107·2	125·0
513	35·65	71·30	107·0	124·7
514	35·57	71·14	106·7	124·5
515	35·50	71·00	106·5	124·3
516	35·44	70·88	106·3	124·1
517	35·37	70·74	106·1	123·8
518	35·30	70·60	105·9	123·6
519	35·23	70·46	105·7	123·3
520	35·17	70·34	105·5	123·1
521	35·10	70·20	105·3	122·8
522	35·02	70·04	105·1	122·6
523	34·96	69·92	104·9	122·4
524	34·89	69·78	104·7	122·1
525	34·82	69·64	104·5	121·9
526	34·76	69·52	104·3	121·7
527	34·69	69·38	104·1	121·4
528	34·63	69·26	103·9	121·2

TABLE XXIX.—*Continued.*

I. No.	II. 40	III 80	IV. 120	V. 140
529	34.56	69.12	103.7	121.0
530	34.49	68.98	103.5	120.7
531	34.43	68.86	103.3	120.5
532	34.38	68.76	103.1	120.3
533	34.31	68.62	102.9	120.1
534	34.25	68.50	102.8	119.9
535	34.18	68.36	102.5	119.6
536	34.11	68.22	102.3	119.4
537	34.05	68.10	102.2	119.2
538	33.98	67.98	101.9	118.9
539	33.92	67.84	101.7	118.7
540	33.86	67.72	101.6	118.5
541	33.80	67.60	101.4	118.3
542	33.74	67.48	101.2	118.1
543	33.67	67.34	101.0	117.8
544	33.61	67.22	100.8	117.6
545	33.55	67.10	100.7	117.4
546	33.49	66.98	100.5	117.2
547	33.42	66.84	100.3	117.0
548	33.37	66.74	100.1	116.8
549	33.31	66.62	99.93	116.6
550	33.24	66.48	99.72	116.4
551	33.18	66.36	99.54	116.1
552	33.13	66.26	99.39	115.9
553	33.07	66.14	99.21	115.7
554	33.01	66.02	99.03	115.5
555	32.95	65.90	98.85	115.3
556	32.89	65.78	98.67	115.1
557	32.83	65.66	98.49	114.9
558	32.77	65.54	98.31	114.7
559	32.71	65.42	98.13	114.5
560	32.65	65.30	97.95	114.3
561	32.58	65.16	97.74	114.1

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
562	32.54	65.08	97.62	113.9
563	32.48	64.96	97.44	113.7
564	32.42	64.84	97.26	113.5
565	32.37	64.74	97.11	113.3
566	32.30	64.60	96.90	113.1
567	32.25	64.50	96.75	112.9
568	32.20	64.40	96.60	112.7
569	32.14	64.28	96.42	112.5
570	32.08	64.16	96.24	112.3
571	32.03	64.06	96.09	112.1
572	31.97	63.94	95.91	111.9
573	31.91	63.82	95.73	111.7
574	31.85	63.70	95.55	111.5
575	31.80	63.60	95.40	111.3
576	31.75	63.50	95.25	111.1
577	31.69	63.38	95.07	110.9
578	31.63	63.26	94.89	110.7
579	31.58	63.16	94.74	110.5
580	31.53	63.06	94.59	110.4
581	31.48	62.96	94.44	110.2
582	31.42	62.84	94.26	110.0
583	31.36	62.72	94.08	109.7
584	31.31	62.62	93.93	109.6
585	31.26	62.52	93.78	109.4
586	31.20	62.40	93.60	109.2
587	31.16	62.32	93.48	109.0
588	31.10	62.20	93.30	108.8
589	31.05	62.10	93.15	108.6
590	30.99	61.98	92.97	108.5
591	30.94	61.88	92.82	108.3
592	30.89	61.78	92.67	108.1
593	30.83	61.66	92.49	107.9
594	30.78	61.56	92.34	107.7

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
595	30·73	61·46	92·19	107·6
596	30·68	61·36	92·04	107·5
597	30·63	61·26	91·89	107·2
598	30·58	61·16	91·74	107·0
599	30·53	61·06	91·59	106·9
600	30·48	60·96	91·44	106·7
601	30·42	60·84	91·26	106·5
602	30·38	60·76	91·14	106·3
603	30·33	60·66	90·99	106·1
604	30·28	60·56	90·84	106·0
605	30·22	60·44	90·66	105·8
606	30·17	60·34	90·51	105·6
607	30·12	60·24	90·36	105·4
608	30·07	60·14	90·21	105·2
609	30·02	60·04	90·06	105·1
610	29·97	59·94	89·91	104·9
611	29·93	59·86	89·79	104·7
612	29·87	59·74	89·61	104·5
613	29·83	59·66	89·49	104·4
614	29·78	59·56	89·34	104·2
615	29·73	59·46	89·19	104·1
616	29·68	59·36	89·04	103·9
617	29·63	59·26	88·89	103·7
618	29·59	59·18	88·77	103·6
619	29·54	59·08	88·62	103·4
620	29·49	58·98	88·47	103·2
621	29·45	58·90	88·35	103·1
622	29·40	58·80	88·20	102·9
623	29·35	58·70	88·05	102·7
624	29·30	58·60	87·90	102·6
625	29·25	58·50	87·75	102·4
626	29·20	58·40	87·60	102·2
627	29·16	58·32	87·48	102·1

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
628	29.12	58.24	87.36	101.9
629	29.07	58.14	87.21	101.7
630	29.02	58.04	87.06	101.6
631	28.98	57.96	86.94	101.4
632	28.94	57.88	86.82	101.3
633	28.89	57.78	86.67	101.1
634	28.84	57.68	86.52	100.9
635	28.79	57.58	86.37	100.8
636	28.75	57.50	86.25	100.6
637	28.71	57.42	86.13	100.5
638	28.66	57.32	85.98	100.3
639	28.62	57.24	85.86	100.2
640	28.57	57.14	85.71	100.0
641	28.52	57.04	85.56	99.82
642	28.48	56.96	85.44	99.68
643	28.44	56.88	85.32	99.54
644	28.39	56.78	85.17	99.37
645	28.34	56.68	85.02	99.19
646	28.31	56.62	84.93	99.08
647	28.26	56.52	84.78	98.91
648	28.21	56.42	84.63	98.74
649	28.18	56.36	84.54	98.63
650	28.13	56.26	84.39	98.46
651	28.08	56.16	84.24	98.28
652	28.05	56.10	84.15	98.17
653	28.00	56.00	84.00	98.00
654	27.96	55.92	83.88	97.86
655	27.92	55.84	83.76	97.72
656	27.87	55.74	83.61	97.56
657	27.83	55.66	83.49	97.40
658	27.79	55.58	83.37	97.27
659	27.74	55.48	83.22	97.09
660	27.71	55.42	83.13	96.99



TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
661	27.67	55.34	83.01	96.84
662	27.62	55.24	82.86	96.67
663	27.58	55.16	82.74	96.53
664	27.54	55.08	82.62	96.39
665	27.50	55.00	82.50	96.25
666	27.46	54.92	82.38	96.11
667	27.42	54.84	82.26	95.97
668	27.37	54.74	82.11	95.80
669	27.33	54.66	81.99	95.66
670	27.29	54.58	81.87	95.52
671	27.26	54.52	81.78	95.41
672	27.21	54.42	81.63	95.24
673	27.17	54.34	81.51	95.10
674	27.13	54.26	81.39	94.95
675	27.09	54.18	81.27	94.82
676	27.05	54.10	81.15	94.68
677	27.01	54.02	81.03	94.54
678	26.98	53.96	80.94	94.43
679	26.93	53.86	80.79	94.26
680	26.89	53.78	80.67	94.12
681	26.85	53.70	80.55	93.98
682	26.81	53.62	80.43	93.84
683	26.77	53.54	80.31	93.70
684	26.73	53.46	80.19	93.56
685	26.69	53.38	80.07	93.42
686	26.66	53.32	79.98	93.31
687	26.62	53.24	79.86	93.17
688	26.58	53.16	79.74	93.03
689	26.55	53.10	79.65	92.93
690	26.51	53.02	79.53	92.79
691	26.46	52.92	79.38	92.61
692	26.42	52.84	79.26	92.47
693	26.38	52.76	79.14	92.33

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
694	26.34	52.68	79.02	92.19
695	26.31	52.62	78.93	92.09
696	26.27	52.54	78.81	91.95
697	26.23	52.46	78.69	91.81
698	26.19	52.38	78.57	91.67
699	26.16	52.32	78.48	91.56
700	26.12	52.24	78.36	91.43
701	26.09	52.18	78.27	91.31
702	26.05	52.10	78.15	91.18
703	26.01	52.02	78.05	91.03
704	25.97	51.94	77.91	90.90
705	25.93	51.86	77.79	90.76
706	25.90	51.80	77.70	90.65
707	25.86	51.72	77.58	90.51
708	25.83	51.66	77.49	90.41
709	25.79	51.58	77.37	90.27
710	25.75	51.50	77.25	90.13
711	25.71	51.42	77.13	89.99
712	25.68	51.36	77.04	89.88
713	25.64	51.28	76.92	89.74
714	25.61	51.22	76.83	89.64
715	25.58	51.16	76.74	89.53
716	25.54	51.08	76.62	89.39
717	25.51	51.02	76.53	89.29
718	25.47	50.94	76.41	89.15
719	25.43	50.86	76.29	89.01
720	25.40	50.80	76.20	88.90
721	25.36	50.72	76.08	88.76
722	25.33	50.66	75.99	88.66
723	25.29	50.58	75.87	88.52
724	25.25	50.50	75.75	88.38
725	25.23	50.46	75.69	88.31
726	25.19	50.38	75.57	88.17

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
727	25·16	50·32	75·48	88·06
728	25·12	50·24	75·36	87·92
729	25·08	50·16	75·24	87·78
730	25·05	50·10	75·15	87·68
731	25·01	50·02	75·03	87·54
732	24·98	49·96	74·94	87·43
733	24·95	49·90	74·85	87·33
734	24·91	49·82	74·73	87·19
735	24·88	49·76	74·64	87·08
736	24·84	49·68	74·52	86·94
737	24·80	49·60	74·40	86·80
738	24·77	49·54	74·31	86·70
739	24·75	49·50	74·25	86·63
740	24·71	49·42	74·13	86·49
741	24·68	49·36	74·04	86·38
742	24·64	49·28	73·92	86·24
743	24·61	49·22	73·83	86·14
744	24·58	49·16	73·74	86·03
745	24·54	49·08	73·62	85·89
746	24·51	49·02	73·53	85·79
747	24·47	48·94	73·41	85·66
748	24·44	48·88	73·32	85·54
749	24·41	48·82	73·23	85·44
750	24·38	48·76	73·14	85·33
751	24·35	48·70	73·05	85·23
752	24·32	48·64	72·96	85·12
753	24·29	48·58	72·87	85·02
754	24·25	48·50	72·75	84·88
755	24·22	48·44	72·66	84·77
756	24·18	48·36	72·54	84·63
757	24·15	48·30	72·45	84·53
758	24·12	48·24	72·36	84·42
759	24·09	48·18	72·27	84·32

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
760	24·06	48·12	72·18	84·21
761	24·03	48·06	72·09	84·11
762	24·00	48·00	72·00	84·00
763	23·96	47·92	71·88	83·86
764	23·93	47·86	71·79	83·76
765	23·90	47·80	71·70	83·65
766	23·87	47·74	71·61	83·55
767	23·84	47·68	71·52	83·44
768	23·81	47·62	71·43	83·34
769	23·78	47·56	71·34	83·23
770	23·74	47·48	71·22	83·09
771	23·71	47·42	71·13	82·96
772	23·69	47·38	71·07	82·92
773	23·65	47·30	70·95	82·78
774	23·62	47·24	70·86	82·67
775	23·59	47·18	70·77	82·57
776	23·56	47·12	70·68	82·46
777	23·54	47·08	70·62	82·39
778	23·51	47·02	70·53	82·29
779	23·47	46·94	70·41	82·15
780	23·44	46·88	70·32	82·04
781	23·41	46·82	70·23	81·94
782	23·38	46·76	70·14	81·83
783	23·35	46·70	70·05	81·73
784	23·32	46·64	69·96	81·62
785	23·29	46·58	69·87	81·52
786	23·27	46·54	69·81	81·45
787	23·24	46·48	69·72	81·34
788	23·20	46·40	69·60	81·20
789	23·17	46·34	69·51	81·10
790	23·15	46·30	69·45	81·03
791	23·12	46·24	69·36	80·92
792	23·09	46·18	69·27	80·82

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
793	23·05	46·10	69·15	80·68
794	23·03	46·06	69·09	80·61
795	23·00	46·00	69·00	80·50
796	22·97	45·94	68·91	80·40
797	22·94	45·88	68·82	80·29
798	22·92	45·84	68·76	80·22
799	22·89	45·78	68·67	80·12
800	22·86	45·72	68·58	80·01
801	22·83	45·66	68·49	79·91
802	22·80	45·60	68·40	79·80
803	22·77	45·54	68·31	79·70
804	22·74	45·48	68·22	79·59
805	22·72	45·44	68·16	79·52
806	22·70	45·40	68·10	79·45
807	22·66	45·32	67·98	79·31
808	22·63	45·26	67·89	79·21
809	22·60	45·20	67·80	79·10
810	22·57	45·14	67·71	79·00
811	22·55	45·10	67·65	78·93
812	22·52	45·04	67·56	78·82
813	22·49	44·98	67·47	78·72
814	22·47	44·94	67·41	78·65
815	22·44	44·88	67·32	78·54
816	22·41	44·82	67·23	78·45
817	22·39	44·78	67·17	78·32
818	22·36	44·72	67·08	78·26
819	22·32	44·64	66·96	78·12
820	22·30	44·60	66·90	78·05
821	22·27	44·54	66·81	77·95
822	22·24	44·48	66·72	77·84
823	22·22	44·44	66·66	77·77
824	22·19	44·38	66·57	77·67
825	22·16	44·32	66·48	77·56

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
826	22.14	44.28	66.42	77.49
827	22.11	44.22	66.33	77.39
828	22.09	44.18	66.27	77.32
829	22.06	44.12	66.18	77.21
830	22.03	44.06	66.09	77.11
831	22.01	44.02	66.03	77.04
832	21.98	43.96	65.94	76.93
833	21.96	43.92	65.88	76.86
834	21.93	43.86	65.79	76.76
835	21.90	43.80	65.70	76.65
836	21.87	43.74	65.61	76.55
837	21.85	43.70	65.55	76.48
838	21.82	43.64	65.46	76.37
839	21.79	43.58	65.37	76.27
840	21.77	43.54	65.31	76.20
841	21.74	43.48	65.22	76.09
842	21.72	43.44	65.16	76.02
843	21.69	43.38	65.07	75.92
844	21.67	43.34	65.01	75.85
845	21.64	43.28	64.92	75.74
846	21.61	43.22	64.83	75.64
847	21.59	43.18	64.77	75.57
848	21.56	43.12	64.68	75.46
849	21.54	43.08	64.62	75.39
850	21.51	43.02	64.53	75.29
851	21.48	42.96	64.44	75.18
852	21.46	42.92	64.38	75.11
853	21.44	42.88	64.32	74.04
854	21.41	42.82	64.23	74.94
855	21.38	42.76	64.14	74.83
856	21.36	42.72	64.08	74.76
857	21.33	42.66	63.99	74.66
858	21.31	42.62	63.93	74.59

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
859	21·28	42·56	63·84	74·48
860	21·26	42·52	63·78	74·41
861	21·23	42·46	63·69	74·31
862	21·21	42·42	63·63	74·25
863	21·18	42·36	63·54	74·13
864	21·16	42·32	63·48	74·06
865	21·13	42·26	63·39	73·96
866	21·12	42·24	63·36	73·92
867	21·09	42·18	63·27	73·83
868	21·07	42·14	63·21	73·75
869	21·04	42·08	63·12	73·64
870	21·02	42·04	63·06	73·57
871	20·99	41·98	62·97	73·47
872	20·97	41·94	62·91	73·40
873	20·94	41·88	62·82	73·29
874	20·92	41·84	62·76	73·22
875	20·89	41·78	62·67	73·12
876	20·87	41·74	62·61	73·05
877	20·85	41·70	62·55	72·98
878	20·83	41·66	62·49	72·91
879	20·80	41·60	62·40	72·80
880	20·78	41·56	62·34	72·73
881	20·75	41·50	62·25	72·63
882	20·73	41·46	62·19	72·56
883	20·70	41·40	62·10	72·45
884	20·68	41·36	62·04	72·38
885	20·66	41·32	61·98	72·31
886	20·64	41·28	61·92	72·24
887	20·62	41·24	61·86	72·17
888	20·60	41·20	61·80	72·10
889	20·57	41·14	61·71	71·99
890	20·54	41·08	61·62	71·89
891	20·52	41·04	61·56	71·82

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
892	20.49	40.98	61.47	71.72
893	20.47	40.94	61.41	71.65
894	20.46	40.92	61.38	71.61
895	20.43	40.86	61.29	71.51
896	20.41	40.82	61.23	71.45
897	20.38	40.76	61.14	71.33
898	20.36	40.72	61.08	71.26
899	20.33	40.66	60.99	71.16
900	20.32	40.64	60.96	71.12
901	20.30	40.60	60.90	71.05
902	20.27	40.54	60.81	70.95
903	20.25	40.50	60.75	70.88
904	20.22	40.44	60.66	70.77
905	20.20	40.40	60.60	70.70
906	20.18	40.36	60.54	70.63
907	20.16	40.32	60.48	70.56
908	20.14	40.28	60.42	70.49
909	20.11	40.22	60.33	70.39
910	20.09	40.18	60.27	70.32
911	20.07	40.14	60.21	70.25
912	20.04	40.08	60.12	70.14
913	20.03	40.06	60.09	70.11
914	20.01	40.02	60.03	70.04
915	19.98	39.96	59.94	69.93
916	19.96	39.92	59.88	69.86
917	19.94	39.88	59.82	69.79
918	19.92	39.84	59.76	69.72
919	19.90	39.80	59.70	69.65
920	19.87	39.74	59.61	69.55
921	19.86	39.72	59.58	69.51
922	19.84	39.68	59.52	69.44
923	19.81	39.62	59.43	69.35
924	19.79	39.58	59.37	69.22



TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
925	19.77	39.54	59.31	69.15
926	19.74	39.48	59.32	69.09
927	19.72	39.44	59.16	69.02
928	19.71	39.42	59.13	68.99
929	19.68	39.36	59.04	68.88
930	19.66	39.32	58.98	68.81
931	19.64	39.28	58.92	68.74
932	19.62	39.24	58.86	68.67
933	19.60	39.20	58.80	68.60
934	19.58	39.16	58.74	68.53
935	19.55	39.10	58.65	68.43
936	19.54	39.08	58.62	68.39
937	19.52	39.04	58.56	68.32
938	19.49	38.98	58.47	68.22
939	19.47	38.94	58.41	68.15
940	19.45	38.90	58.35	68.08
941	19.43	38.86	58.29	68.01
942	19.41	38.82	58.23	67.94
943	19.39	38.74	58.17	67.87
944	19.36	38.72	58.08	67.76
945	19.35	38.70	58.05	67.73
946	19.33	38.66	57.99	67.66
947	19.32	38.64	57.96	67.62
948	19.29	38.58	57.87	67.52
949	19.27	38.54	57.81	67.45
950	19.25	38.50	57.75	67.38
951	19.23	38.46	57.69	67.31
952	19.21	38.42	57.63	67.24
953	19.19	38.38	57.57	67.17
954	19.17	38.34	57.51	67.10
955	19.15	38.30	57.45	67.03
956	19.13	38.26	57.39	66.96
957	19.11	38.22	57.33	66.89

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
958	19.08	38.16	57.24	66.78
959	19.06	38.12	57.18	66.71
960	19.04	38.08	57.12	66.64
961	19.03	38.06	57.09	66.61
962	19.01	38.02	57.03	66.54
963	18.99	37.98	56.97	66.47
964	18.97	37.94	56.91	66.39
965	18.95	37.90	56.85	66.33
966	18.92	37.84	56.76	66.22
967	18.91	37.82	56.73	66.19
968	18.89	37.78	56.67	66.12
969	18.87	37.74	56.61	66.05
970	18.85	37.70	56.55	65.98
971	18.83	37.66	56.49	65.93
972	18.81	37.62	56.43	65.84
973	18.79	37.58	56.37	65.77
974	18.77	37.54	56.31	65.70
975	18.75	37.50	56.25	65.63
976	18.74	37.48	56.22	65.59
977	18.72	37.44	56.16	65.52
978	18.69	37.38	56.07	65.42
979	18.67	37.34	56.01	65.35
980	18.66	37.32	55.98	65.31
981	18.64	37.28	55.92	65.24
982	18.62	37.24	55.86	65.17
983	18.60	37.20	55.80	65.10
984	18.58	37.16	55.74	65.03
985	18.57	37.14	55.71	64.95
986	18.55	37.10	55.65	64.93
987	18.52	37.04	55.56	64.82
988	18.50	37.00	55.50	64.75
989	18.49	36.98	55.47	64.72
990	18.47	36.94	55.41	64.65

TABLE XXIX.—*Continued.*

I. No.	II. 40	III. 80	IV. 120	V. 140
991	18.45	36.90	55.35	64.58
992	18.44	36.88	55.32	64.54
993	18.42	36.84	55.26	64.47
994	18.40	36.80	55.20	64.40
995	18.38	36.76	55.14	64.33
996	18.35	36.70	55.05	64.23
997	18.34	36.68	55.02	64.19
998	18.32	36.64	54.96	64.12
999	18.30	36.60	54.90	64.05
1000	18.28	36.56	54.84	64.00

162. To convert English to Metric count and *vice versa*, formulæ (41) and (42), on p. 69, may be used :—

$$\text{Where } C_E = 8.857 \times 10^{-1} C_M \dots \dots \dots (41)$$

$$\text{and } C_M = 1.129 \times 10^0 C_E \dots \dots \dots (42)$$

163. *Worked Examples.*—1. English 36<sup>s</sup> count. Find Metric count. Substitute in (42)  $C_E = 36$ .

$$\text{Then } C_M = 1.129 \times 10^0 \times 36 = 40.64^s. \text{ Ans.}$$

2. Metric count is 87. Find English count. Substitute in (41)  $C_M = 87$ .

$$\text{Then } C_E = 8.857 \times 10^{-1} \times 87 = 77.06^s. \text{ Ans.}$$

164. By using Table XXX.,

1. Find 36 in No. column ; read 40.64 Metric count.

2. Find 87 in No. column ; read 77.06 English count.

Also, read Sections 14, 92, 94, 102, 103, 107, and 108, on pp. 7, 67, 69, 74, 75, 76, 79, and 80.

## SECTION 165.

## TABLE XXX.

No.	Count.		No.	Count.	
	Metric.	English.		Metric.	English.
1	1.1290	0.8857	33	37.2570	29.2281
2	2.2580	1.7714	34	38.3860	30.1138
3	3.3870	2.6571	35	39.5150	30.9995
4	4.5160	3.5428	36	40.6440	31.8852
5	5.6450	4.4285	37	41.7730	32.7709
6	6.7740	5.3142	38	42.9020	33.6566
7	7.9030	6.1999	39	44.0310	34.5423
8	9.0320	7.0856	40	45.1600	35.4280
9	10.1610	7.9713	41	46.2890	36.3137
10	11.2900	8.8570	42	47.4180	37.1994
11	12.4190	9.7427	43	48.5470	38.0851
12	13.5480	10.6284	44	49.6760	38.9708
13	14.6770	11.5141	45	50.8050	39.8565
14	15.8060	12.3998	46	51.9340	40.7422
15	16.9350	13.2855	47	53.0630	41.6279
16	18.0640	14.1712	48	54.1920	42.5136
17	19.1930	15.0569	49	55.3210	43.3993
18	20.3220	15.9426	50	56.4500	44.2850
19	21.4510	16.8283	51	57.5790	45.1707
20	22.5800	17.7140	52	58.7080	46.0564
21	23.7090	18.5997	53	59.8370	46.9421
22	24.8380	19.4854	54	60.9660	47.8278
23	25.9670	20.3711	55	62.0950	48.7135
24	27.0960	21.2568	56	63.2240	49.5992
25	28.2250	22.1425	57	64.3530	50.4849
26	29.3540	23.0282	58	65.4820	51.3706
27	30.4830	23.9139	59	66.6110	52.2563
28	31.6120	24.7996	60	67.7400	53.1420
29	32.7410	25.6853	61	68.8690	54.0277
30	33.8700	26.5710	62	69.9980	54.9134
31	34.9990	27.4567	63	71.1270	55.7991
32	36.1280	28.3424	64	72.2560	56.6848

TABLE XXX.—*Continued.*

No.	Count.		No.	Count.	
	Metric.	English.		Metric.	English.
65	73.3850	57.5705	96	108.3840	85.0272
66	74.5140	58.4562	97	109.5130	85.9129
67	75.6430	59.3419	98	110.6420	86.7986
68	76.7720	60.2276	99	111.7710	87.6843
69	77.9010	61.1133	100	112.9000	88.5700
70	79.0300	61.9990	101	114.0290	89.4557
71	80.1590	62.8847	102	115.1580	90.3414
72	81.2880	63.7704	103	116.2870	91.2271
73	82.4170	64.6561	104	117.4160	92.1128
74	83.5460	65.5418	105	118.5450	92.9985
75	84.6750	66.4275	106	119.6740	93.8842
76	85.8040	67.3132	107	120.8030	94.7699
77	86.9330	68.1989	108	121.9320	95.6556
78	88.0620	69.0846	109	123.0610	96.5413
79	89.1910	69.9703	110	124.1900	97.4270
80	90.3200	70.8560	111		98.3127
81	91.4490	71.7417	112		99.1984
82	92.5780	72.6274	113		100.0841
83	93.7070	73.5131	114		100.9698
84	94.8360	74.3988	115		101.8555
85	95.9650	75.2845	116		102.7412
86	97.0940	76.1702	117		103.6269
87	98.2230	77.0559	118		104.5126
88	99.3520	77.9416	119		105.3983
89	100.4810	78.8273	120		106.2840
90	101.6100	79.7130	121		107.1697
91	102.7390	80.5987	122		108.0554
92	103.8680	81.4844	123		108.9411
93	104.9970	82.3701	124		109.8268
94	106.1260	83.2558	125		110.7125
95	107.2550	84.1415	126		111.5982

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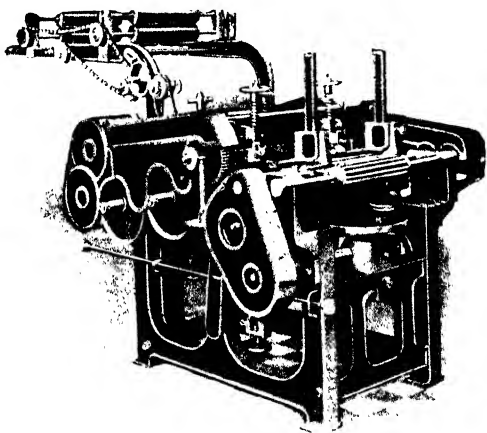




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